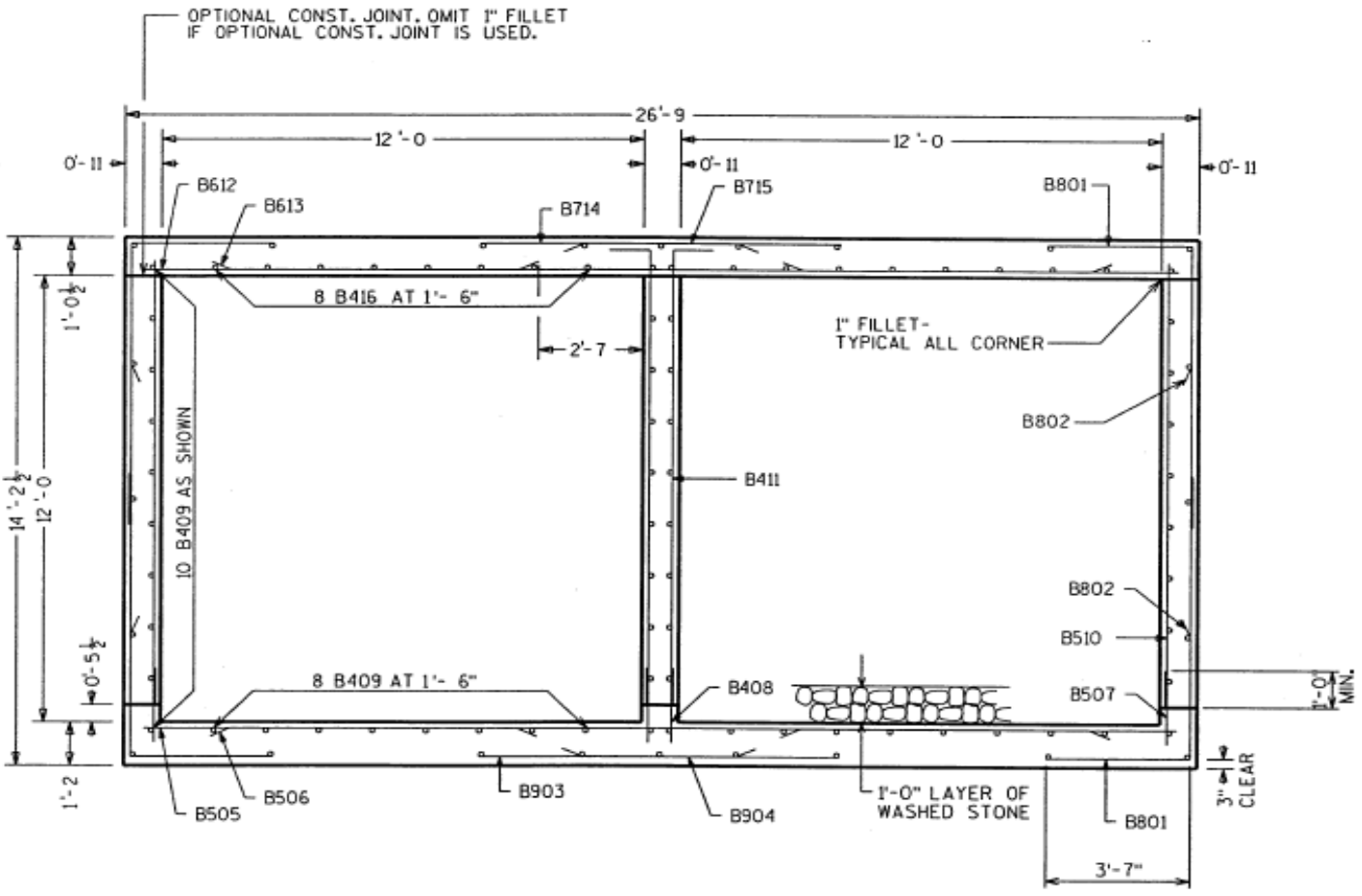
AASHTOWare Bridge Rating and Design Training

CVT1 – Two-Cell RC Box Culvert Example (BrR/BrD 6.4)

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

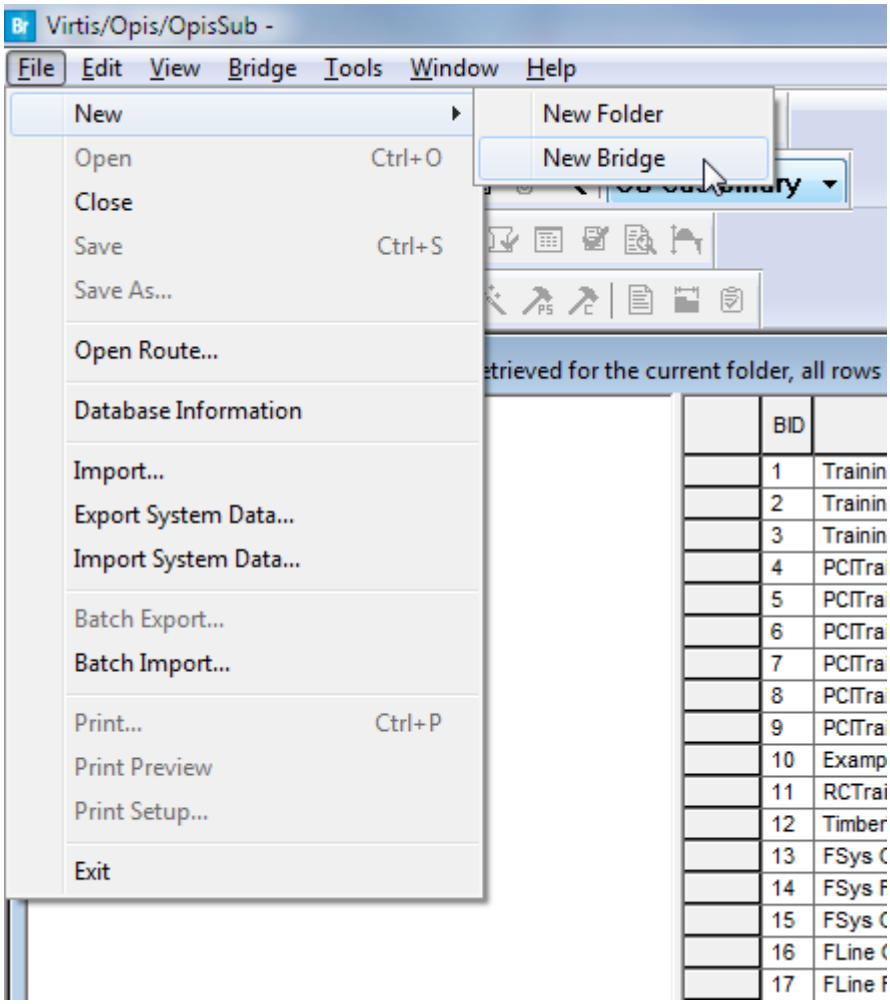
⚠ B801 BARS MAY BE SUBSTITUTED FOR B802 BARS
B903 BARS MAY BE SUBSTITUTED FOR B904 BARS
B505 BARS MAY BE SUBSTITUTED FOR PAIRS OF B506 BARS
B612 BARS MAY BE SUBSTITUTED FOR PAIRS OF B613 BARS
B714 BARS MAY BE SUBSTITUTED FOR B715 BARS.

Material Properties:

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

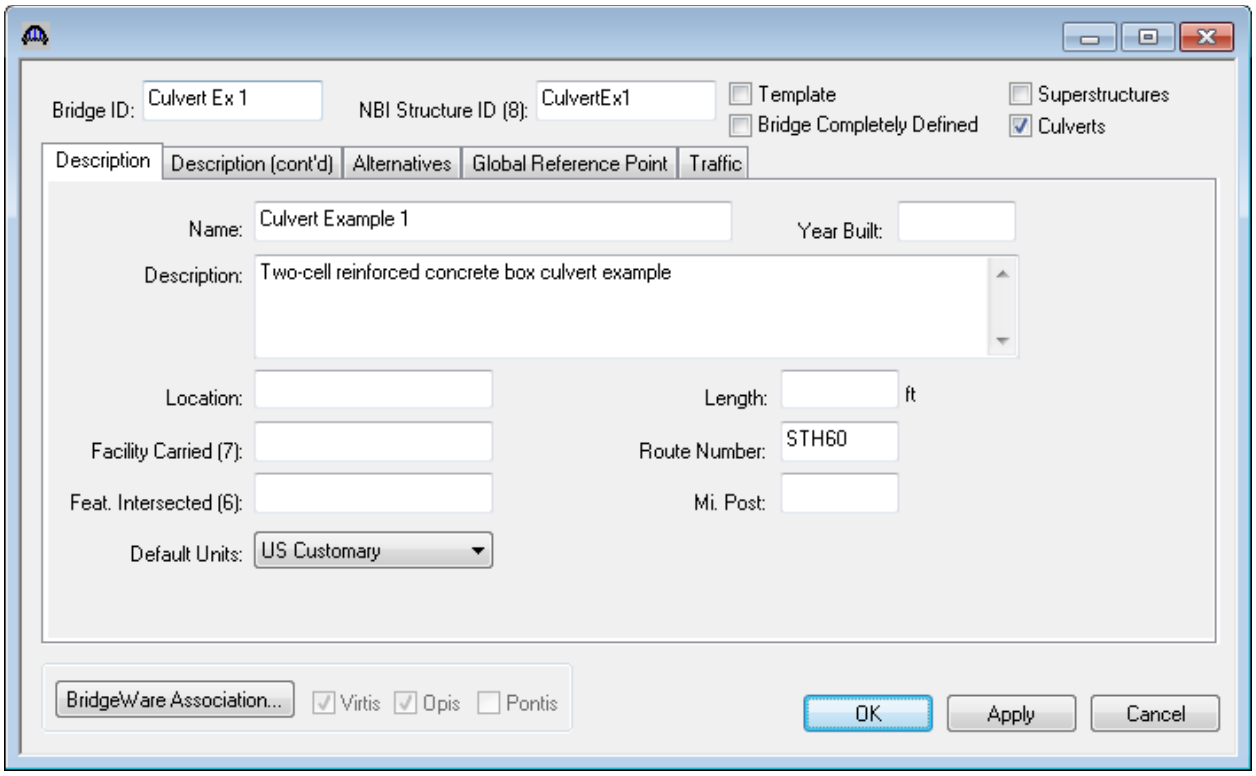
Enter culvert description

From the Bridge Explorer, select File | New | New Bridge to create a new bridge.

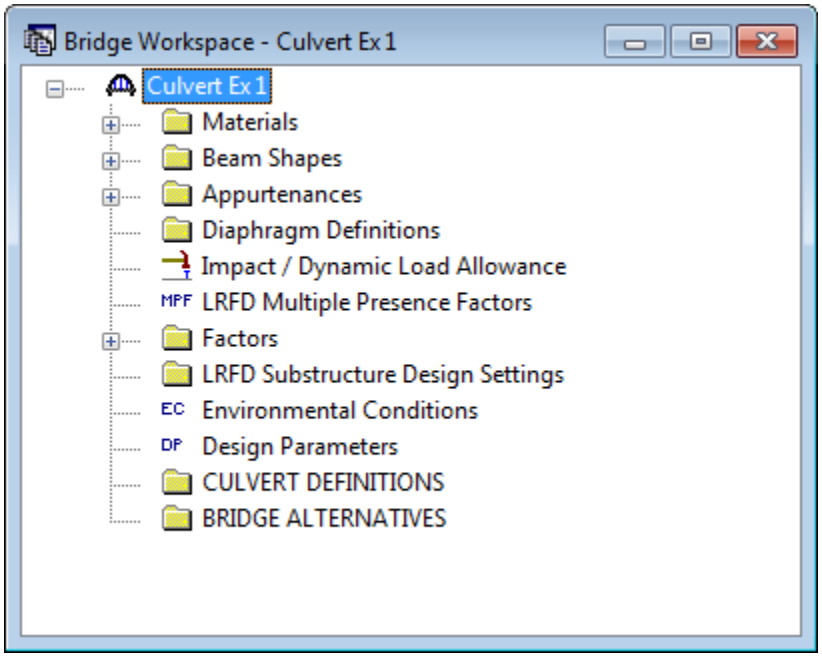


Enter the following description data for the culvert. The Superstructures and Culverts checkboxes specify the types of structures the bridge contains. These checkboxes filter what to display in the Bridge Workspace tree.

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



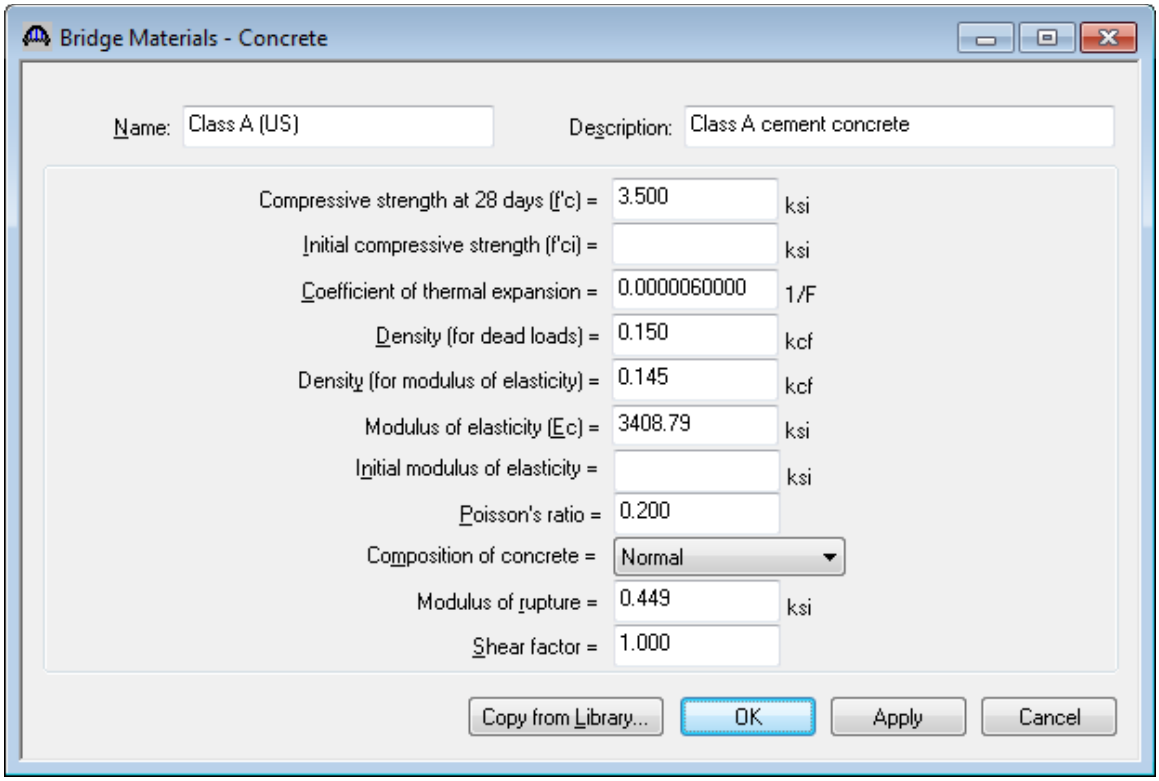
The Bridge Workspace tree after the bridge is created is shown below.



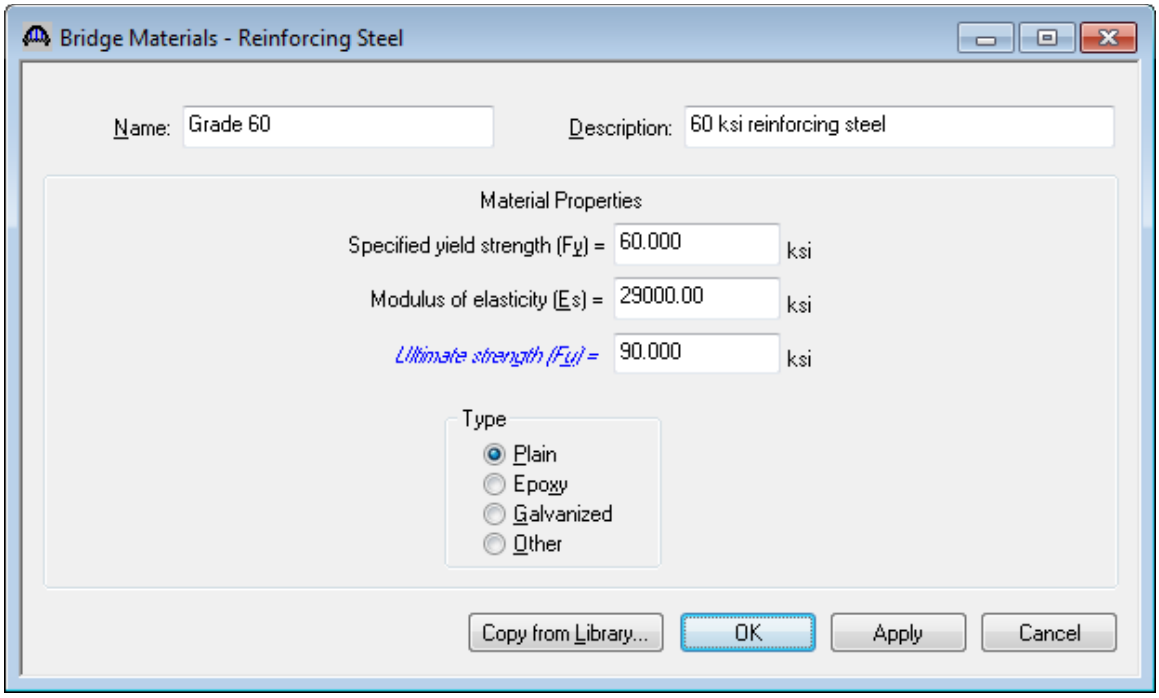
The tree is organized according to the definition of a bridge with data shared by many of the bridge components shown in the upper part of the tree. A bridge can be described by working from top to bottom within the tree.

To enter the materials for the culvert, expand the tree for Materials.

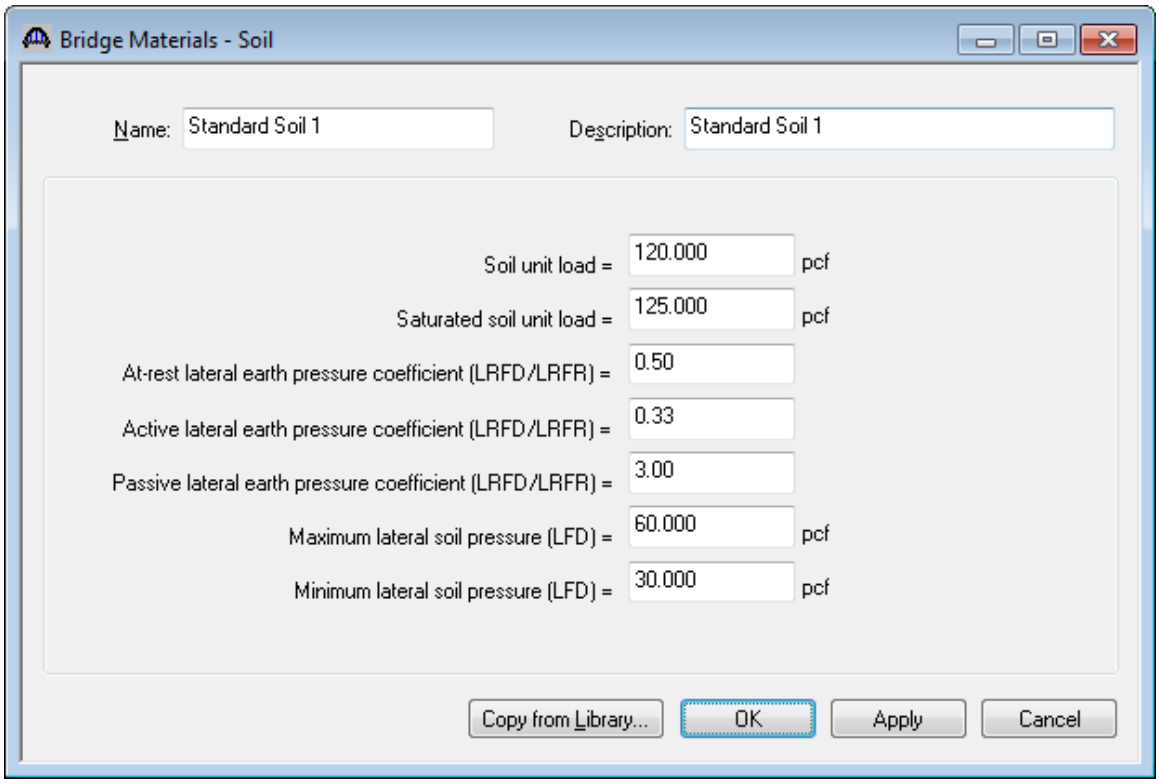
Double-click on the Concrete folder to create a new concrete material. Click on the Copy from Library button to copy the Class A (US) concrete material to the bridge.



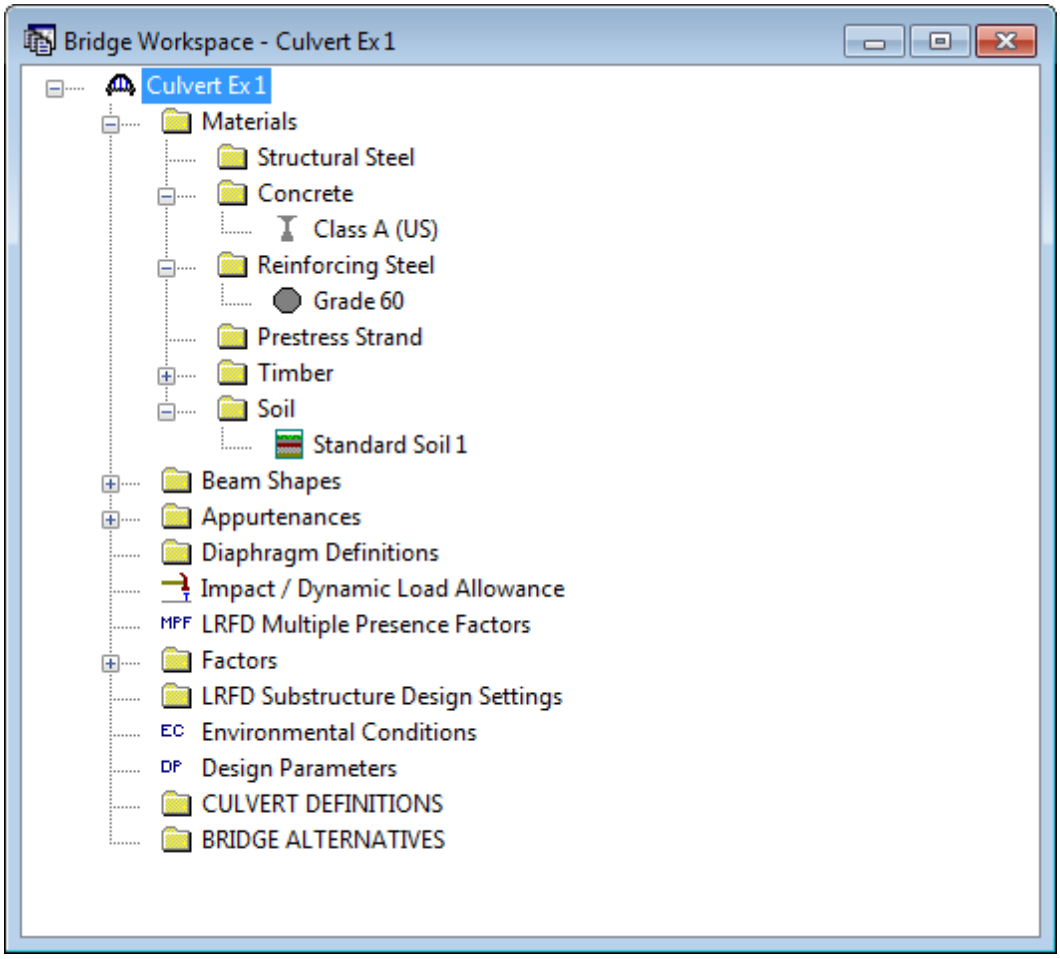
Double-click on the Reinforcing Steel folder to create a new reinforcement material. Click on the Copy from Library button to copy the Grade 60 reinforcement material to the bridge.



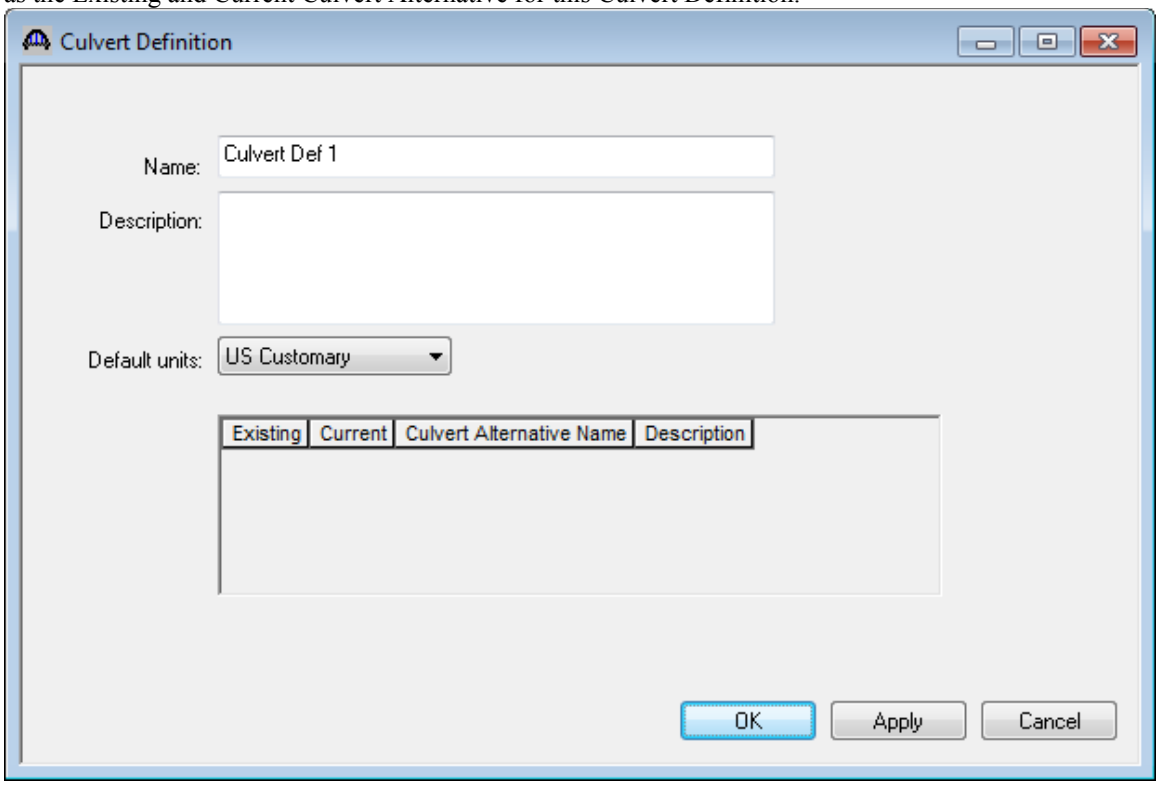
Double-click on the Soil folder to create a new soil material. Click on the Copy from Library button to copy the Standard Soil 1 material to the bridge.



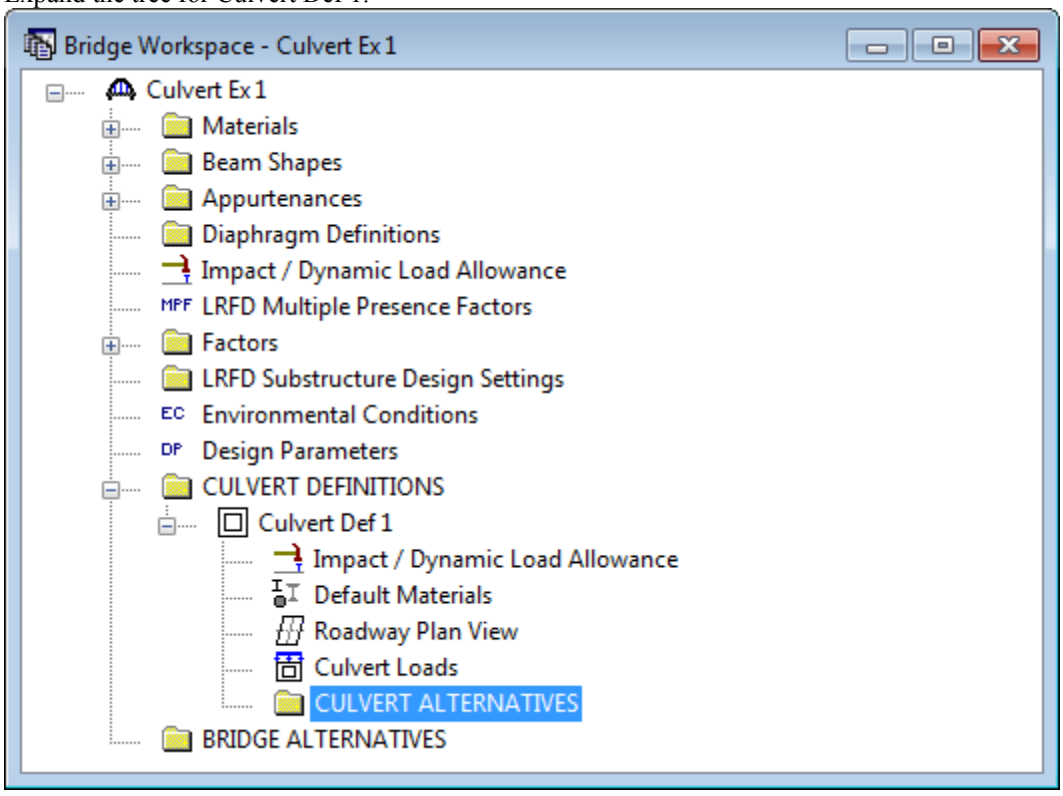
The Bridge Workspace tree with the three materials to be used by the culvert is shown below.



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 that we create will automatically be assigned as the Existing and Current Culvert Alternative for this Culvert Definition.

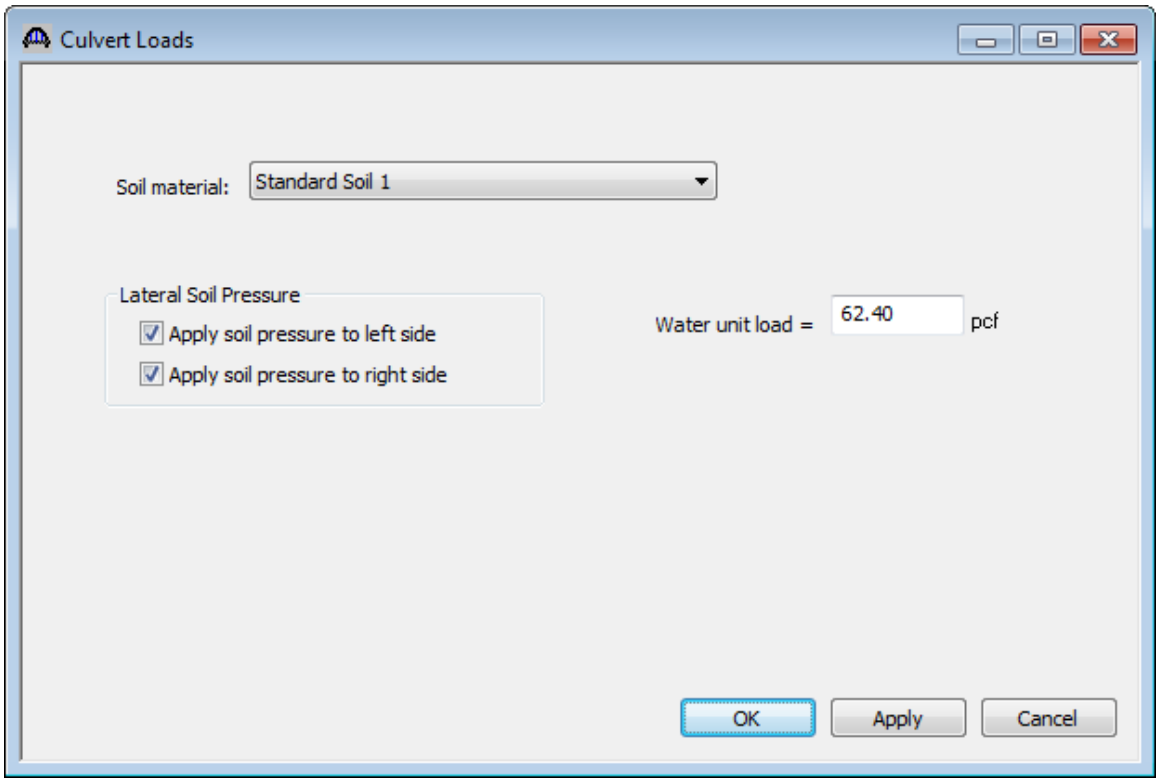


Expand the tree for Culvert Def 1.

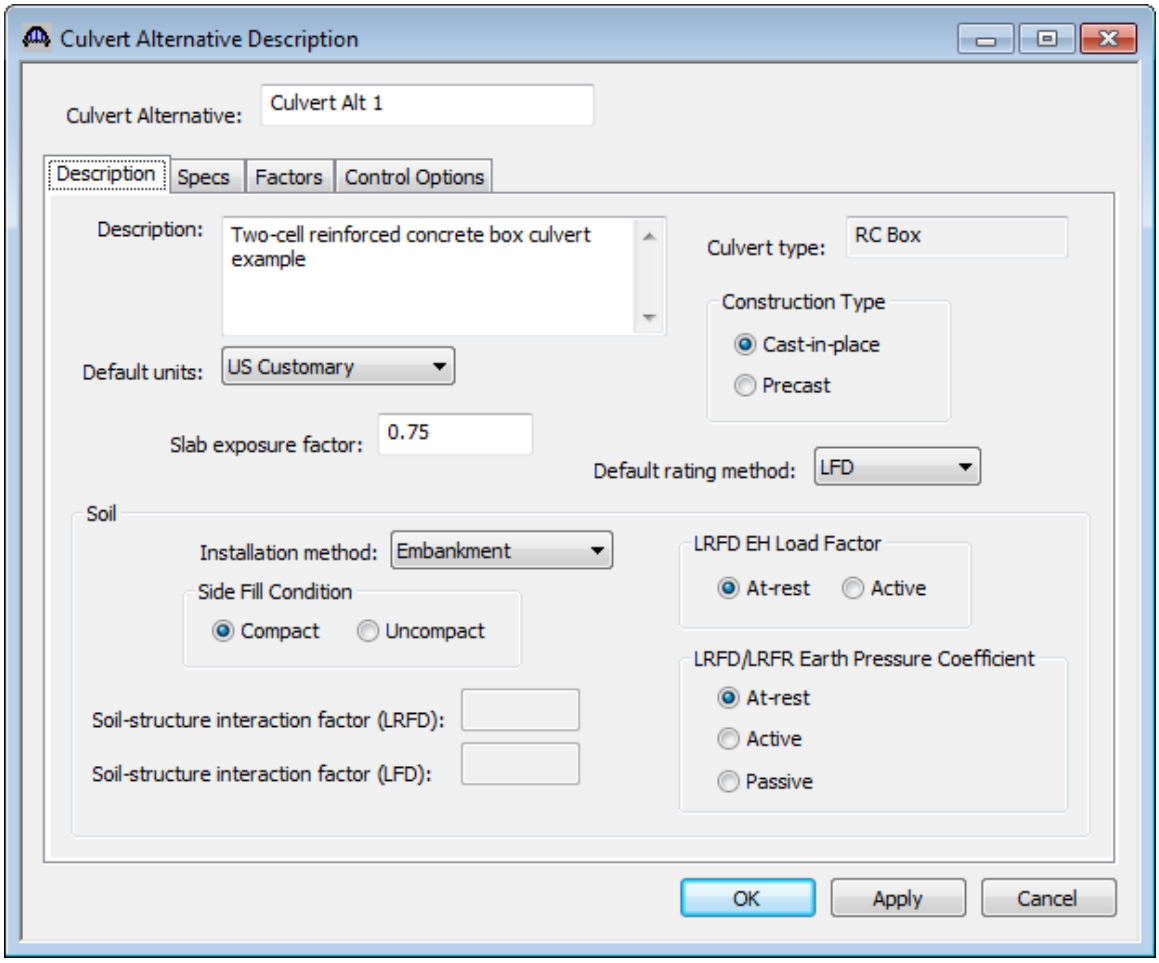


Double-click on Culvert Loads in the tree to open the Culvert Loads window. Select the checkboxes to apply soil pressure to both side of the culvert. These checkboxes are provided to allow for the case where a culvert is widened by placing another culvert directly next to it so that side does not have lateral earth pressure.

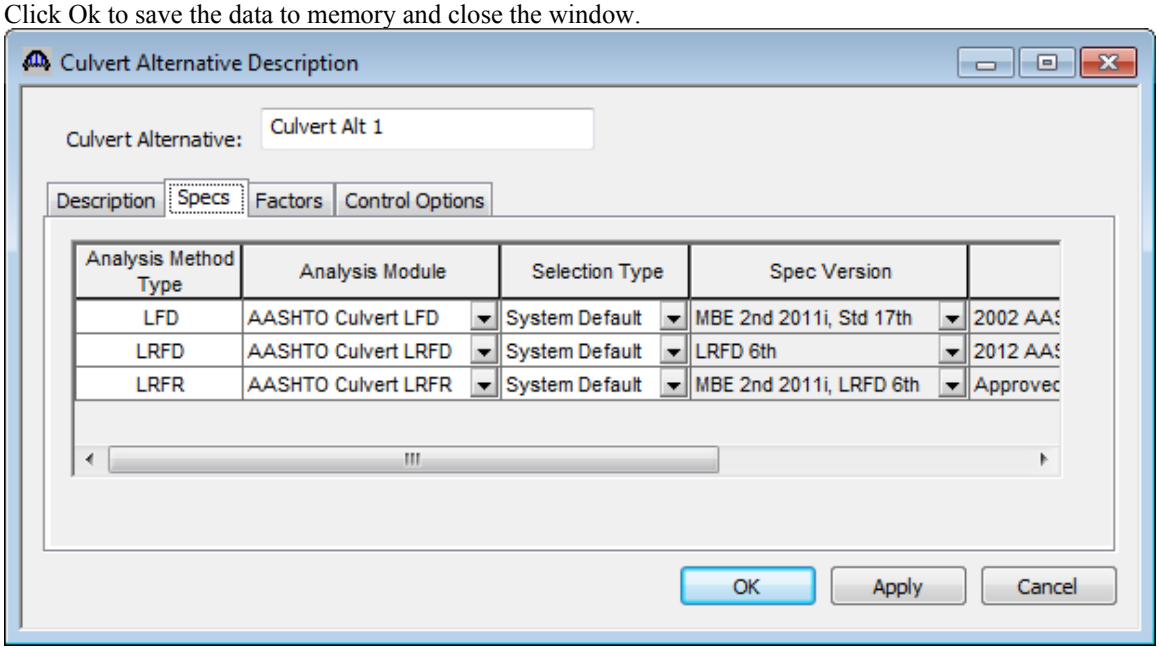
Click Ok to save the data to memory and close the window.



Double-click on the CULVERT ALTERNATIVES folder to create a new culvert alternative for Culvert Def 1. Enter the data as show below.

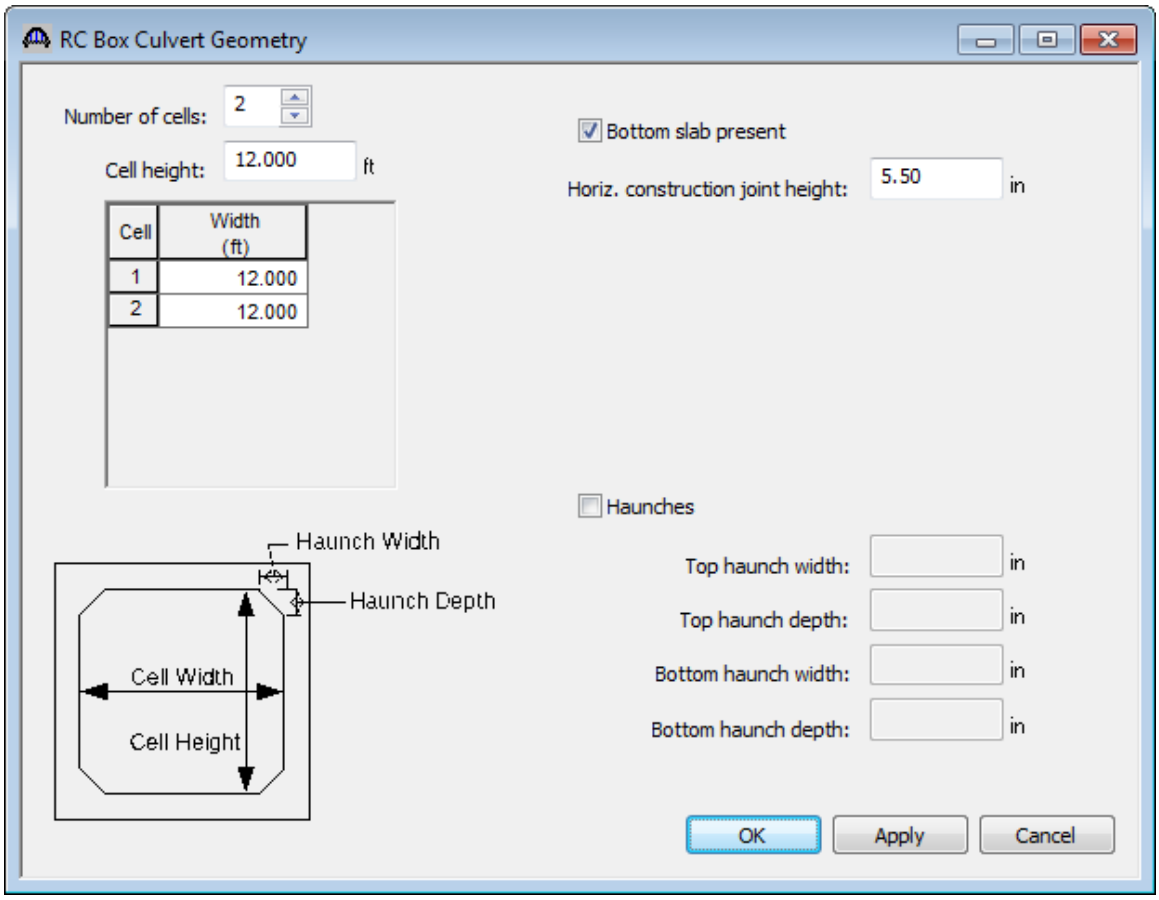


Select the Specs tab. AASHTO Culvert Engine is selected as the analysis module for LRFR analysis. Click Ok to save the data to memory and close the window.



Expand the tree for Culvert Alt 1.

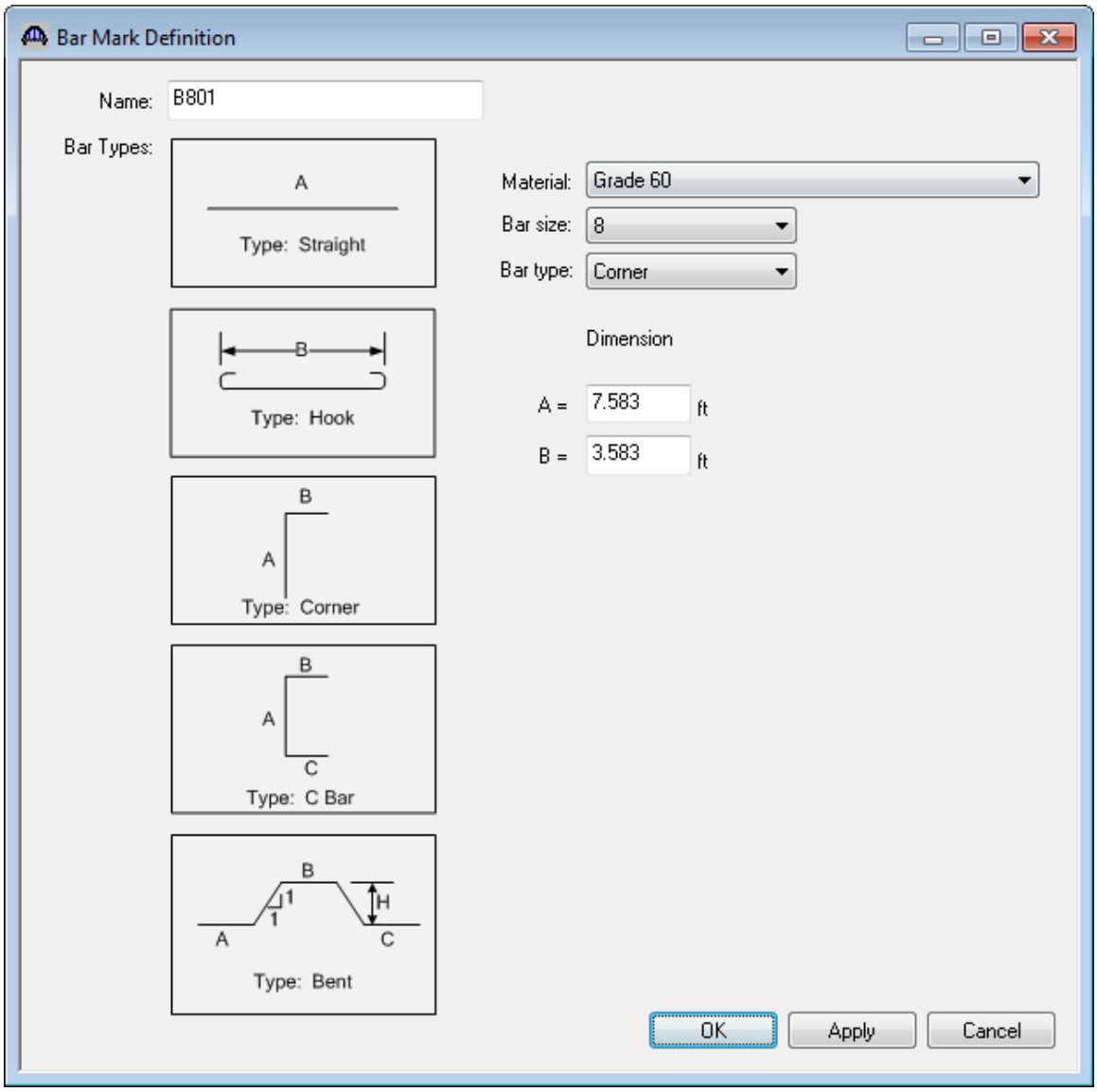
Double-click on RC Box Culvert Geometry in the tree. Enter the data as shown below. Click Ok to save the data to memory and close the window.



Double-click on the Bar Mark Definitions folder in the tree to create a new bar mark definition for Culvert Alt 1.

Enter the data for B801 as shown below. Click Ok to save the data to memory and close the window.

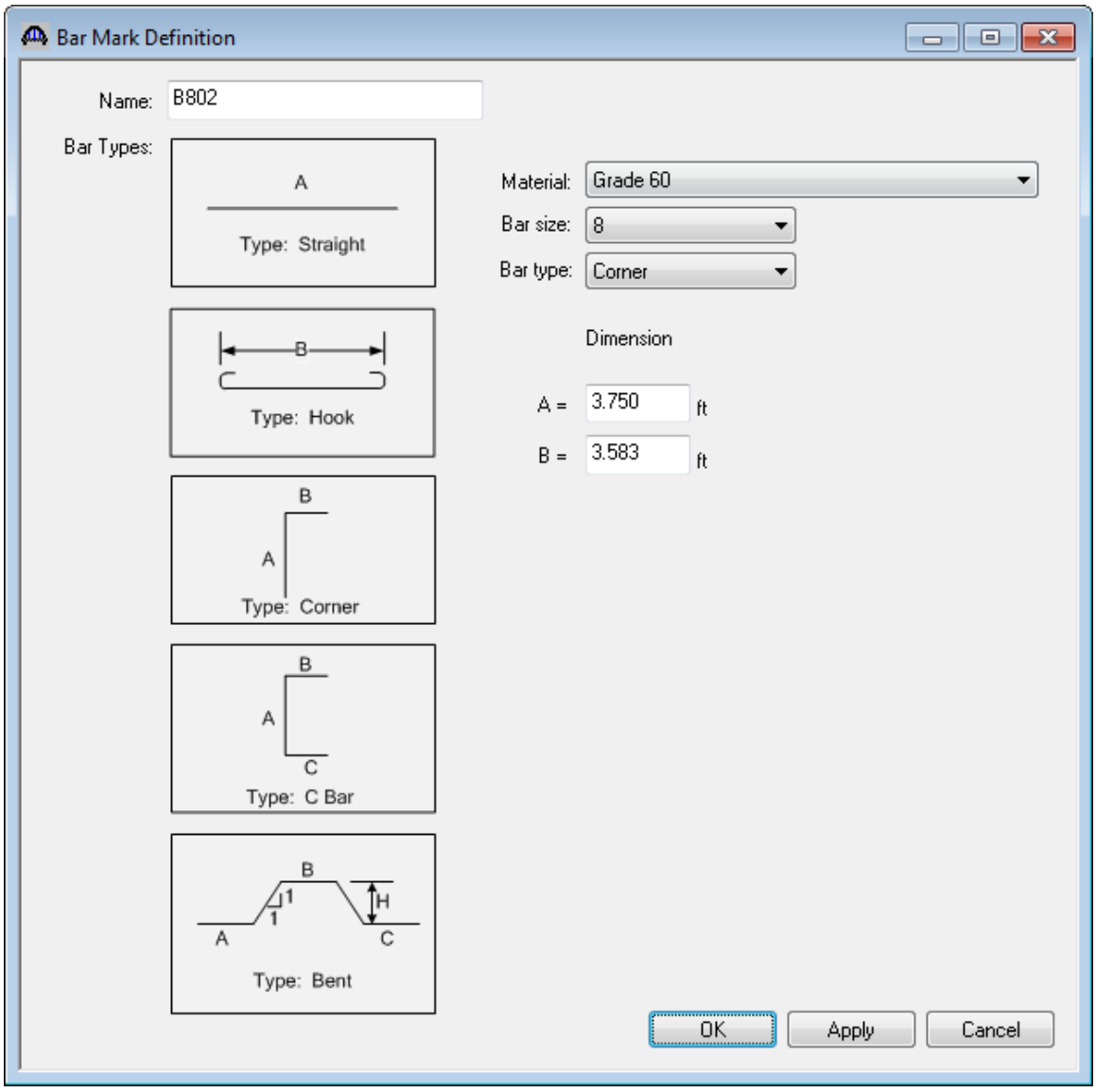
MARK	NUMBER REQ'D.	LENGTH	BENT	CUTTING DIAG.	LOCATION
B801	416	11 -2	3-7	NO	CORNERS



Double-click on the Bar Mark Definitions folder in the tree to create another bar mark definition.

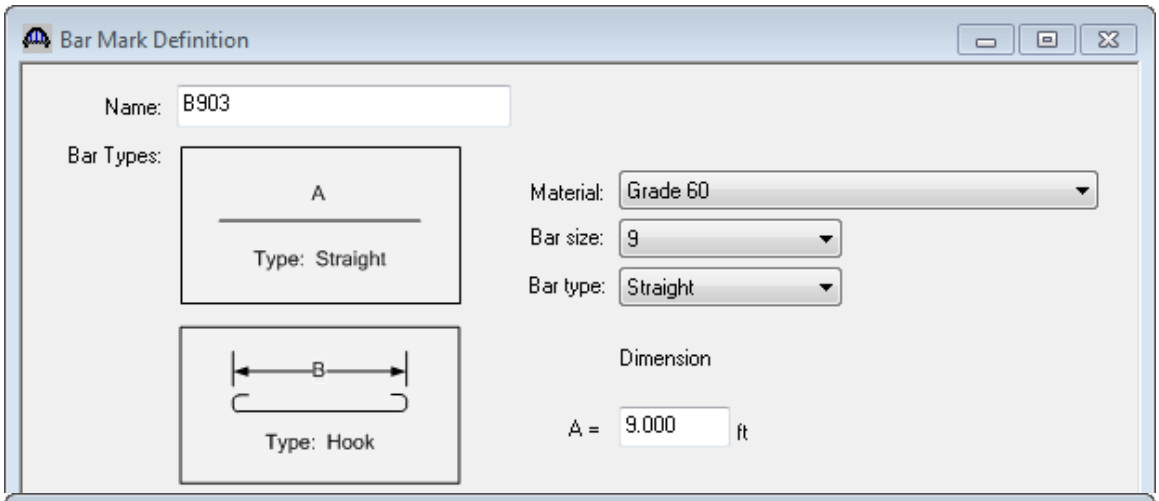
Enter the data for B802 as shown below. Click Ok to save the data to memory and close the window.

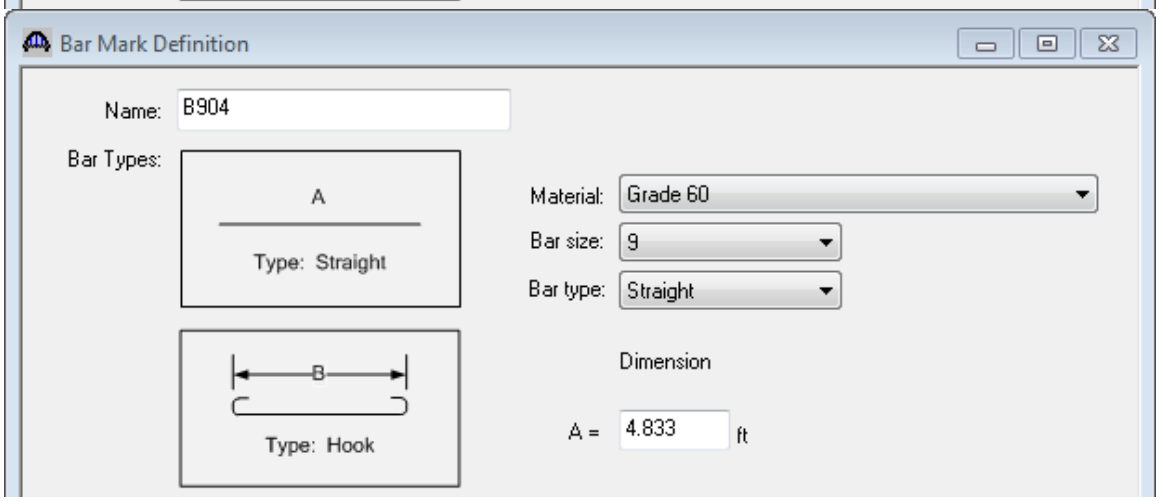
MARK	NUMBER REQ'D.	LENGTH	BENT	CUTTING DIAG.	LOCATION
B802	400	7-4	3-7	NO	CORNERS

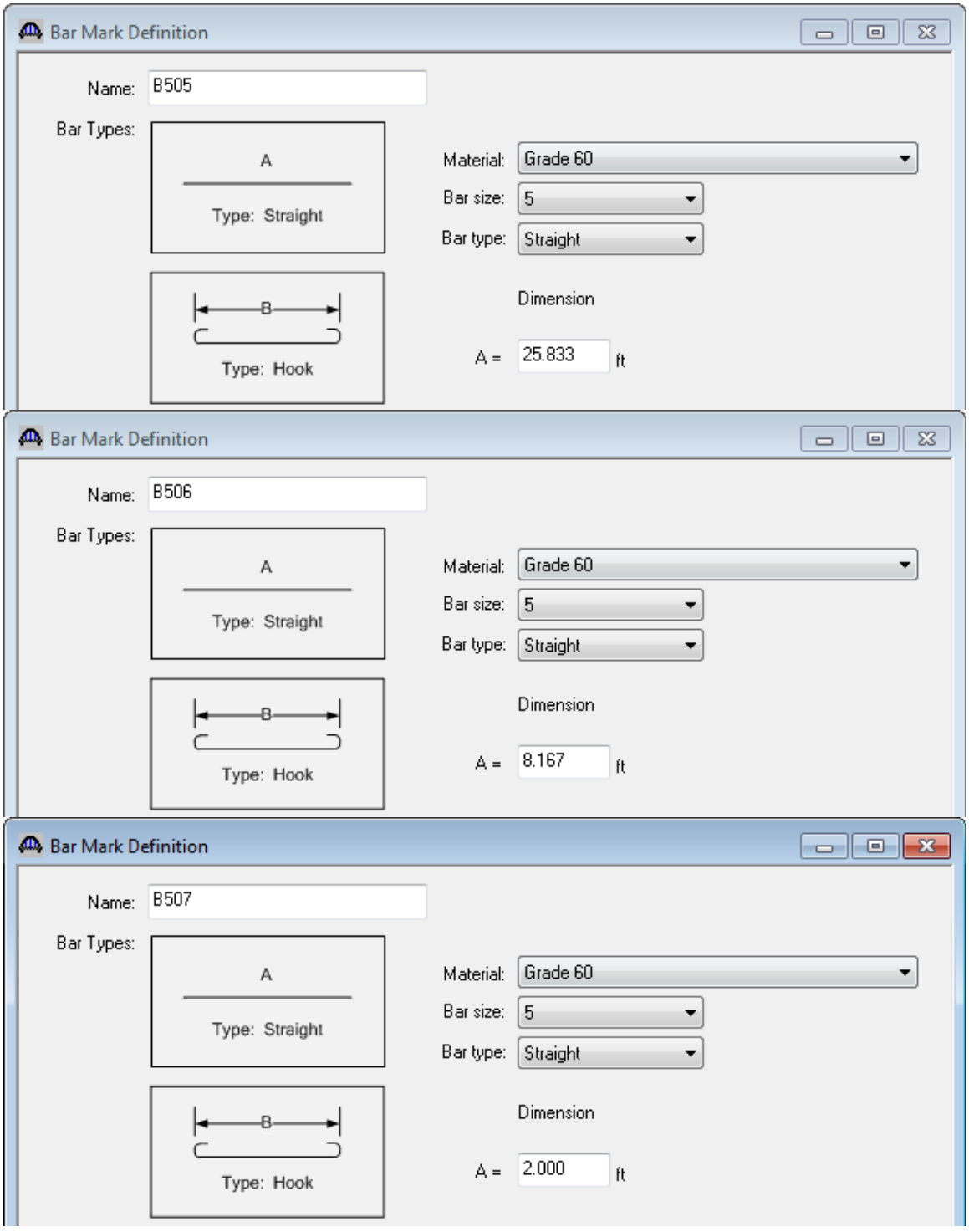


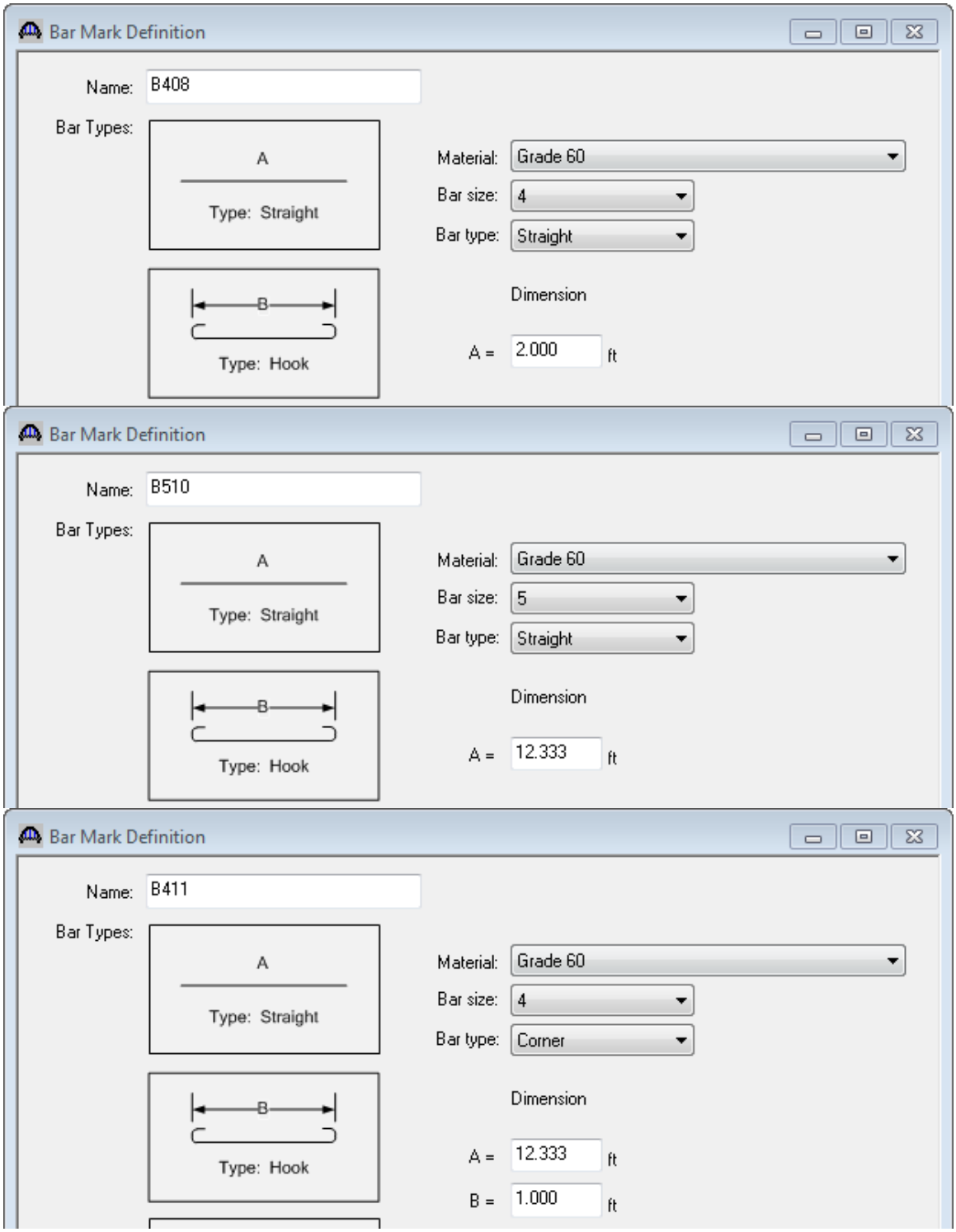
Repeat this process for the rest of the transverse bar marks.

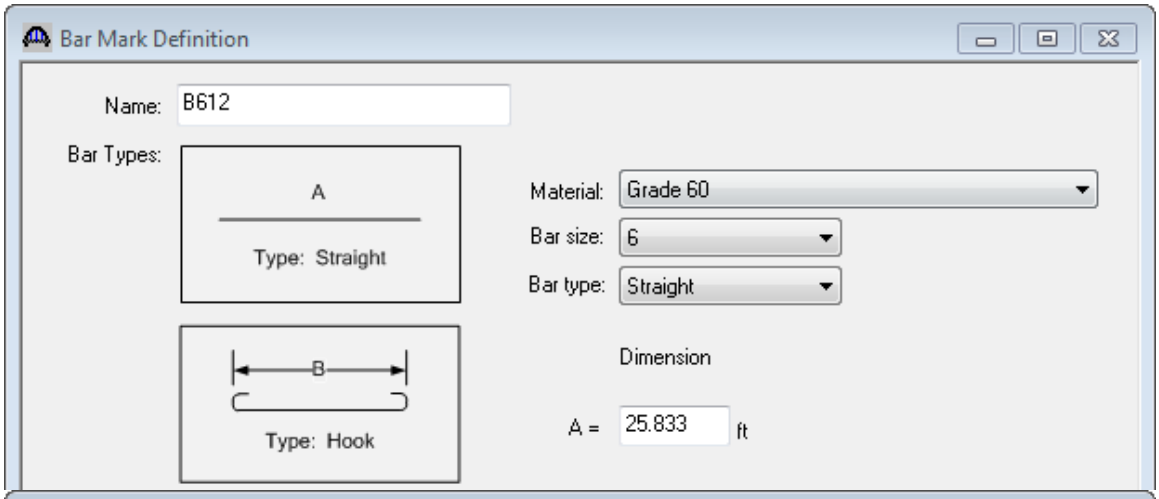
MARK	NUMBER REQ'D.	LENGTH	BENT	CUTTING DIAG.	LOCATION
B903	76	9-0	NO	NO	BOTTOM SLAB TRANS.
B904	72	4-10	NO	NO	BOTTOM SLAB TRANS.
B505	124	25-10	NO	NO	BOTTOM SLAB TRANS.
B506	240	8-2	NO	NO	BOTTOM SLAB TRANS.
B507	296	2-0	NO	NO	WALLS-DOWELS VERT.
B408	136	2-0	NO	NO	WALLS-DOWELS VERT.
B510	296	12-4	NO	NO	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.

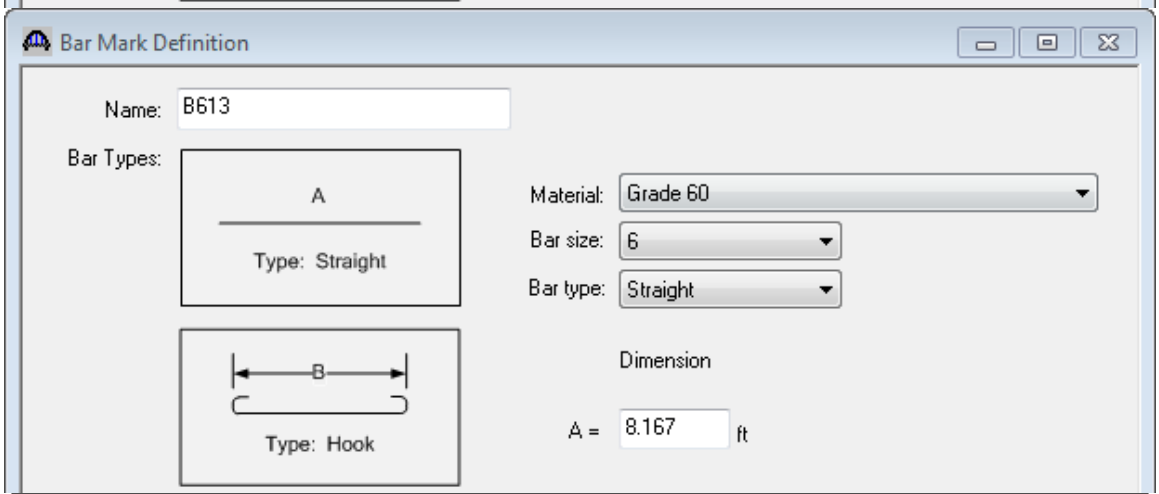


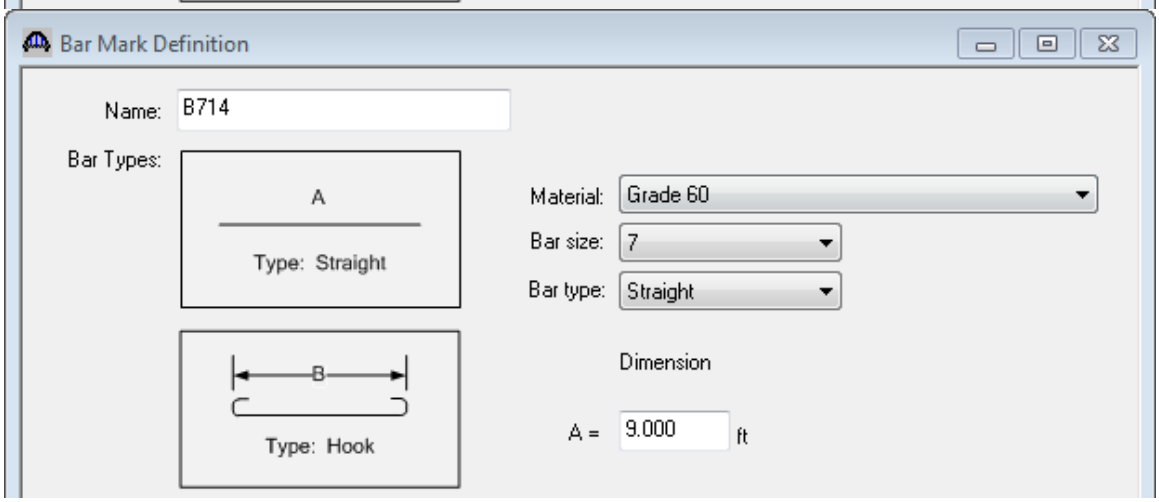


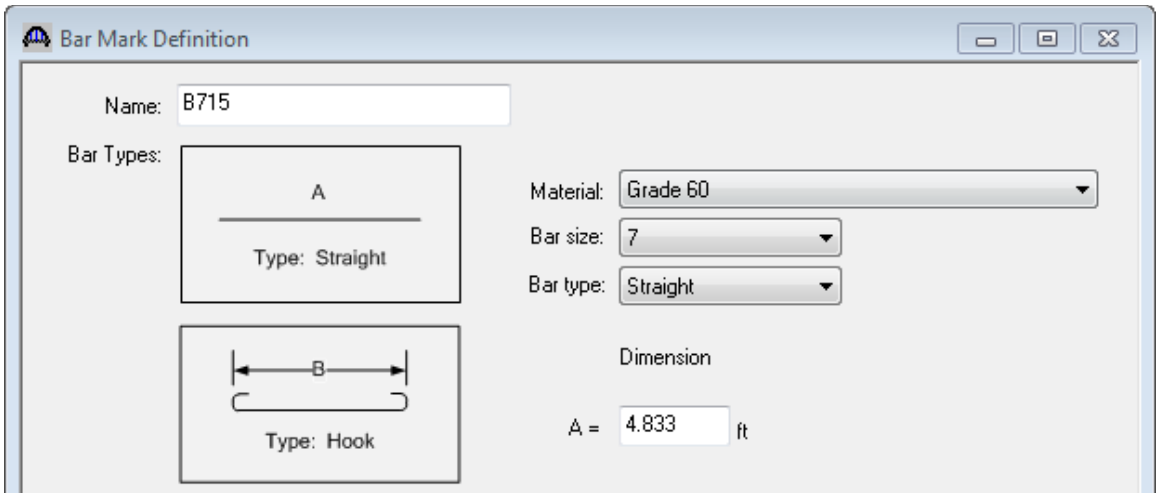

Bar Mark Definition
Name: B505
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 5
Bar type: Straight
Dimension
A = 25.833 ft
Bar Mark Definition
Name: B506
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 5
Bar type: Straight
Dimension
A = 8.167 ft
Bar Mark Definition
Name: B507
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 5
Bar type: Straight
Dimension
A = 2.000 ft


Bar Mark Definition
Name: B408
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 4
Bar type: Straight
Dimension
A = 2.000 ft
Bar Mark Definition
Name: B510
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 5
Bar type: Straight
Dimension
A = 12.333 ft
Bar Mark Definition
Name: B411
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 4
Bar type: Corner
Dimension
A = 12.333 ft
B = 1.000 ft

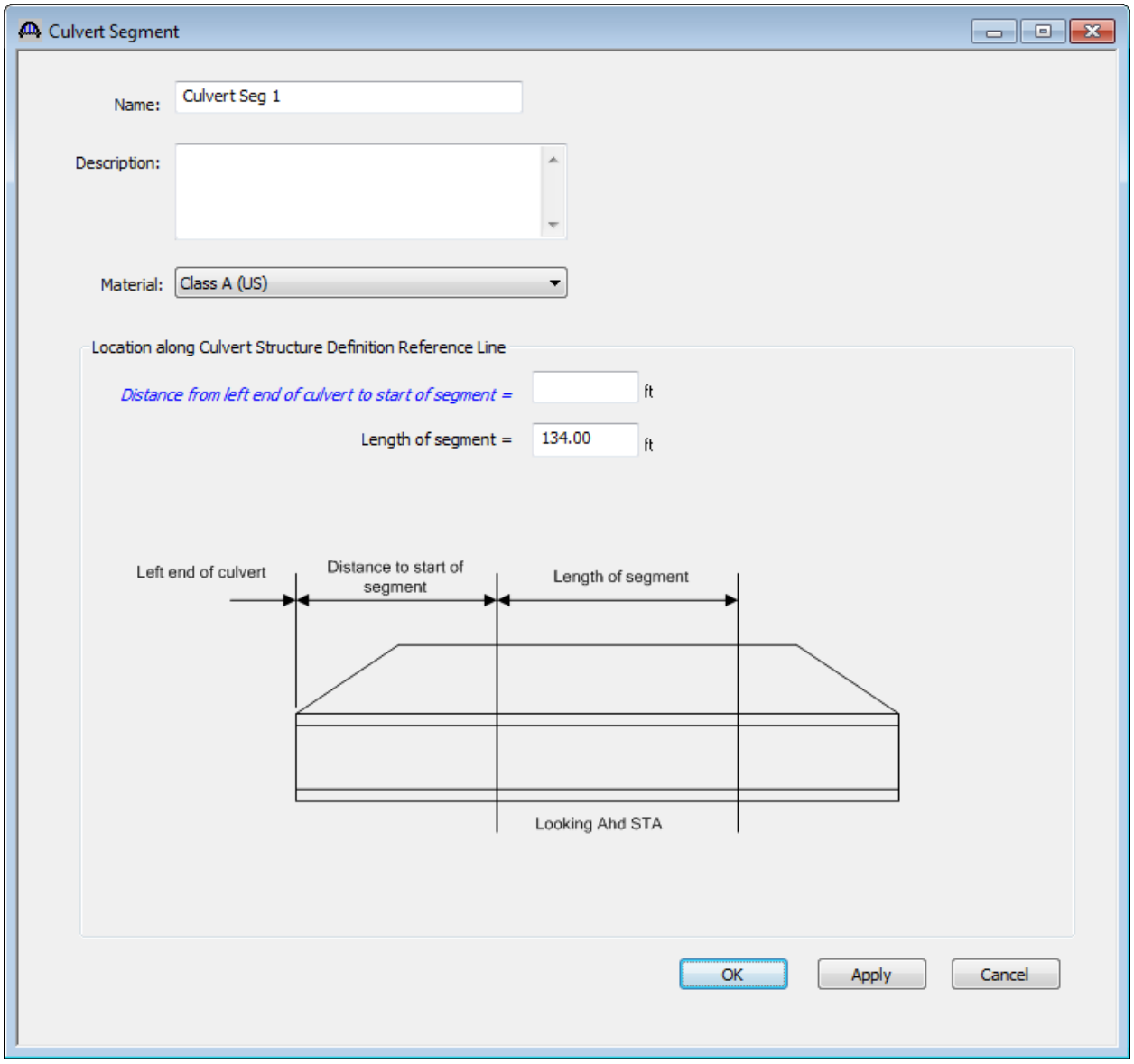

Bar Mark Definition
Name: B612
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 6
Bar type: Straight
Dimension
A = 25.833 ft


Bar Mark Definition
Name: B613
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 6
Bar type: Straight
Dimension
A = 8.167 ft

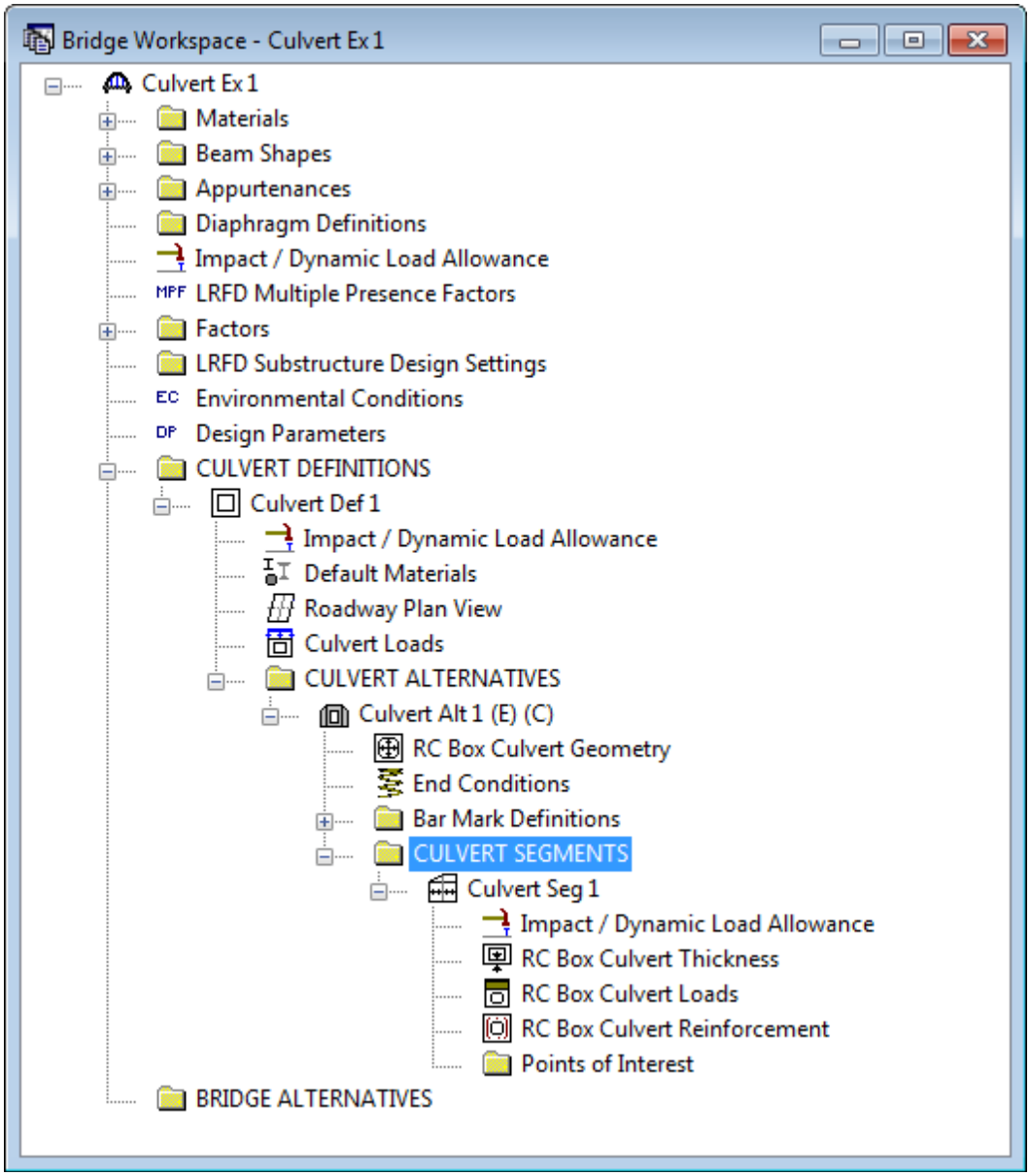

Bar Mark Definition
Name: B714
Bar Types:
A
Type: Straight
B
Type: Hook
Material: Grade 60
Bar size: 7
Bar type: Straight
Dimension
A = 9.000 ft


Bar Mark Definition
Name:
B715
Bar Types:
A
Type: Straight
B
Type: Hook
Material:
Grade 60
Bar size:
7
Bar type:
Straight
Dimension
A =
4.833
ft

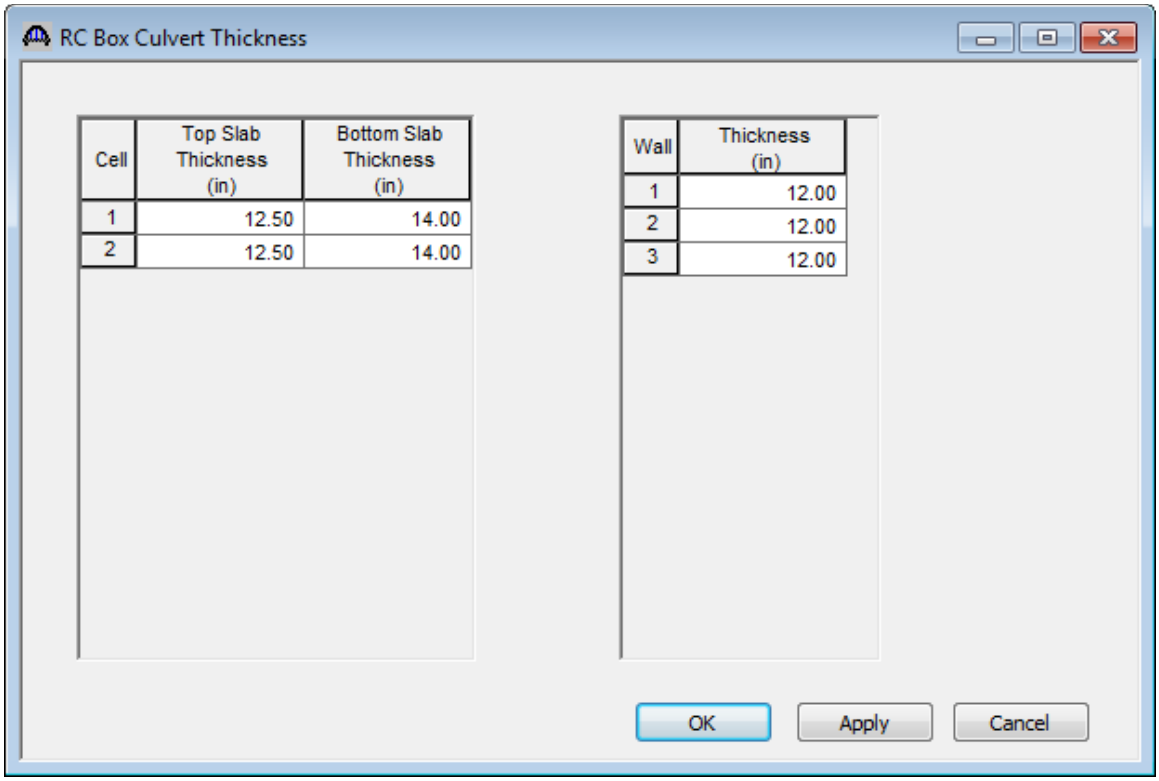
Double-click on the CULVERT SEGMENTS folder to create a new culvert segment for Culvert Alt 1. A culvert alternative may have one or more culvert segments. Enter the data as show below.



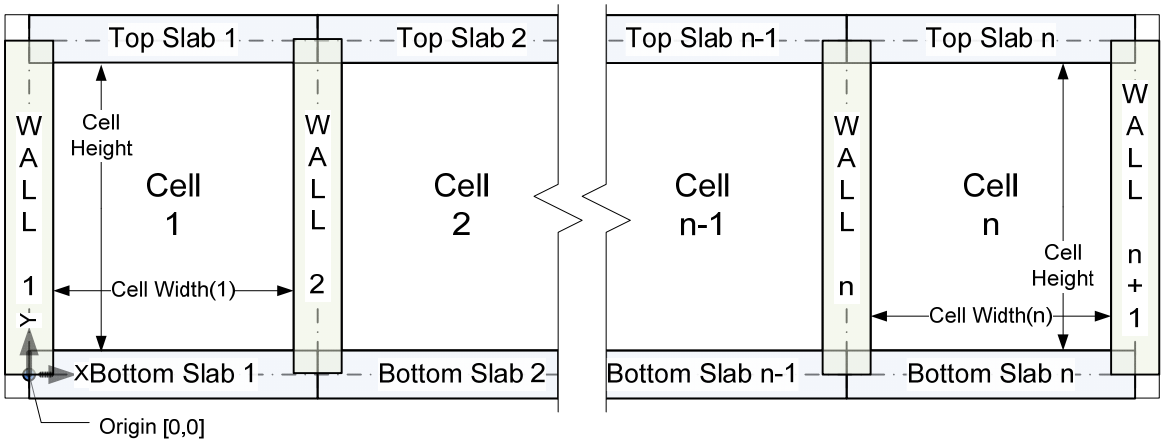
Expand the tree for Culvert Seg 1.



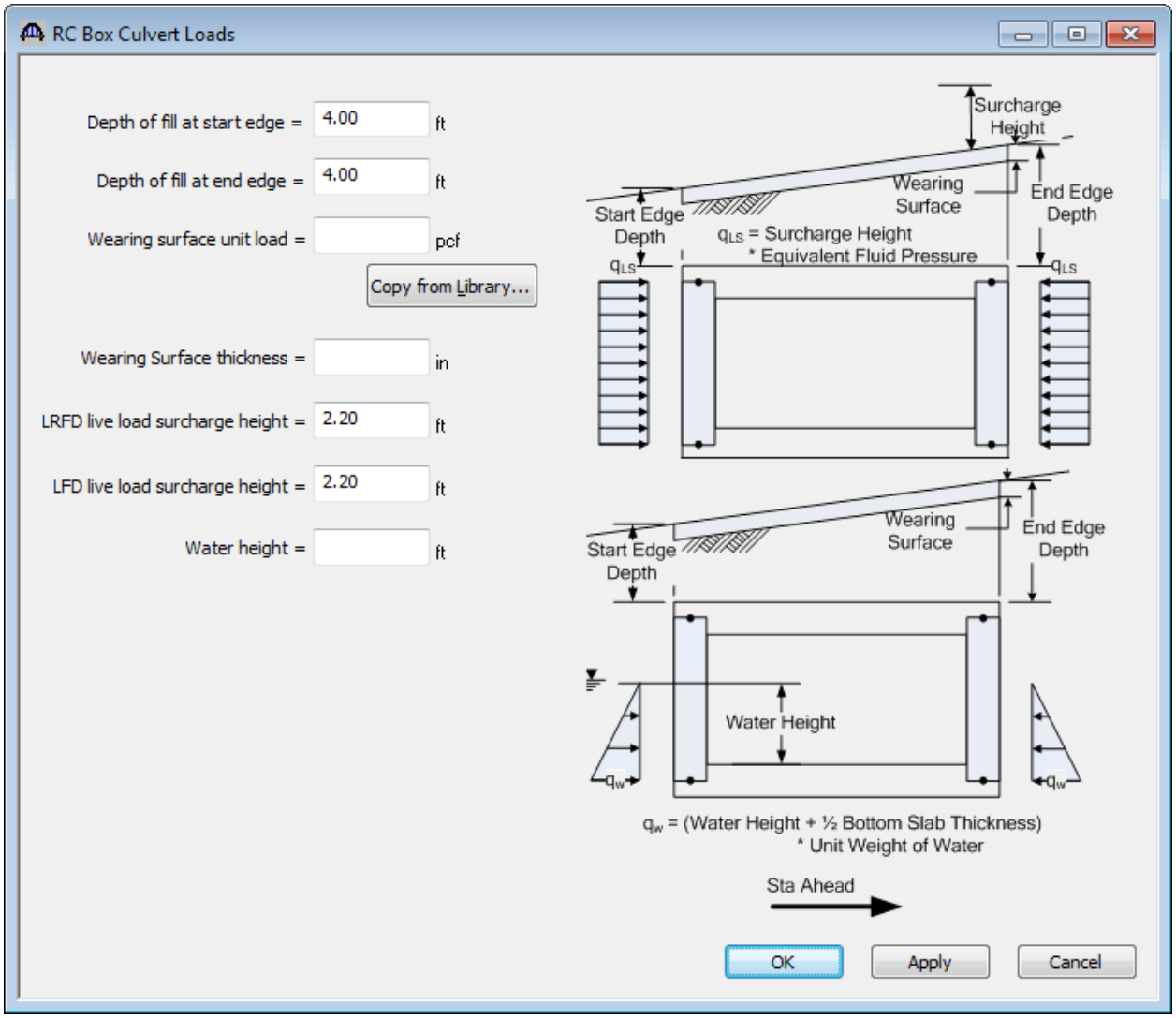
Double-click on RC Box Culvert Thickness in the tree. Enter the slab and wall thicknesses as shown below. Click Ok to save the data to memory and close the window.



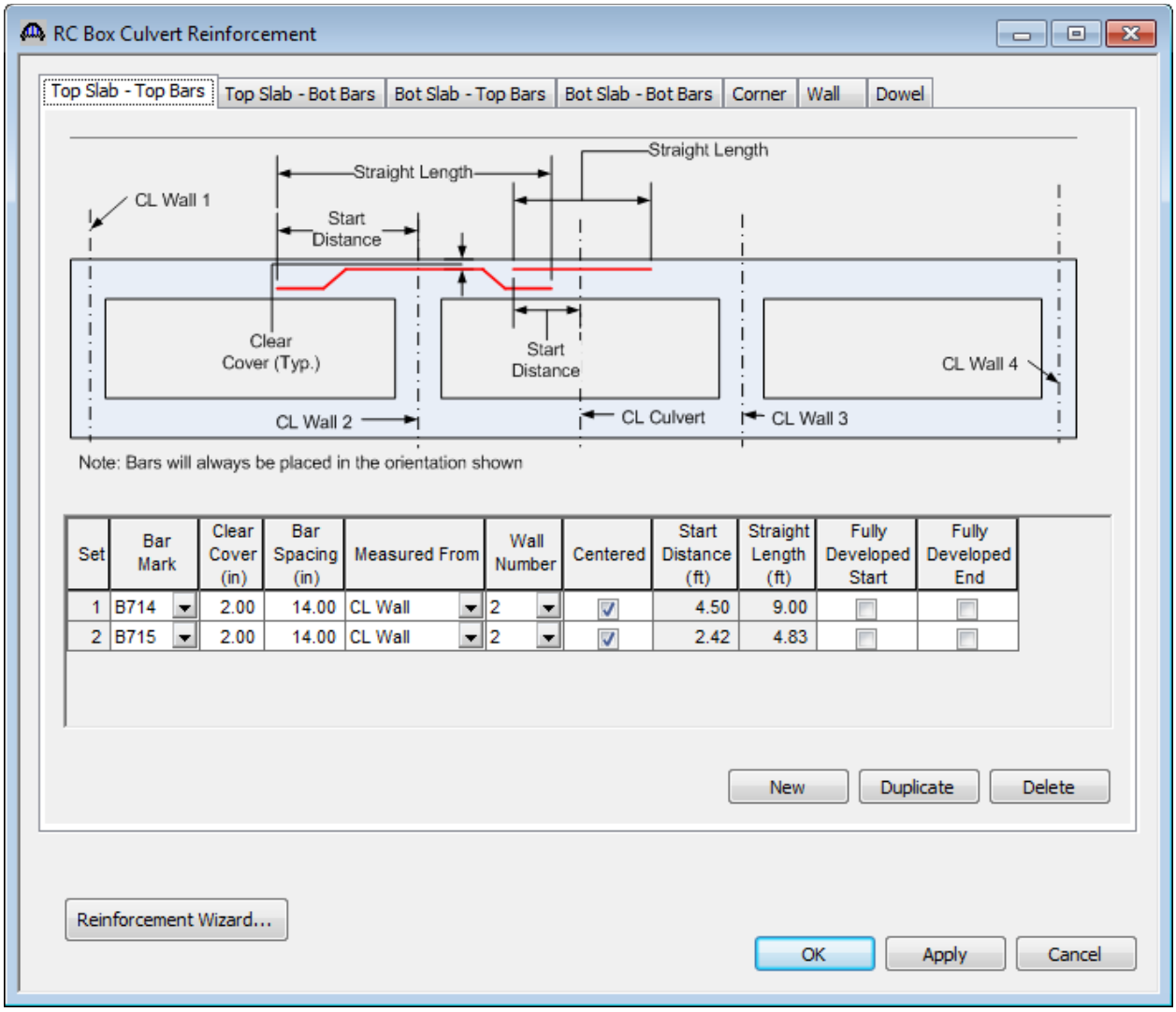
The following shows the components for a box culvert with n cells.

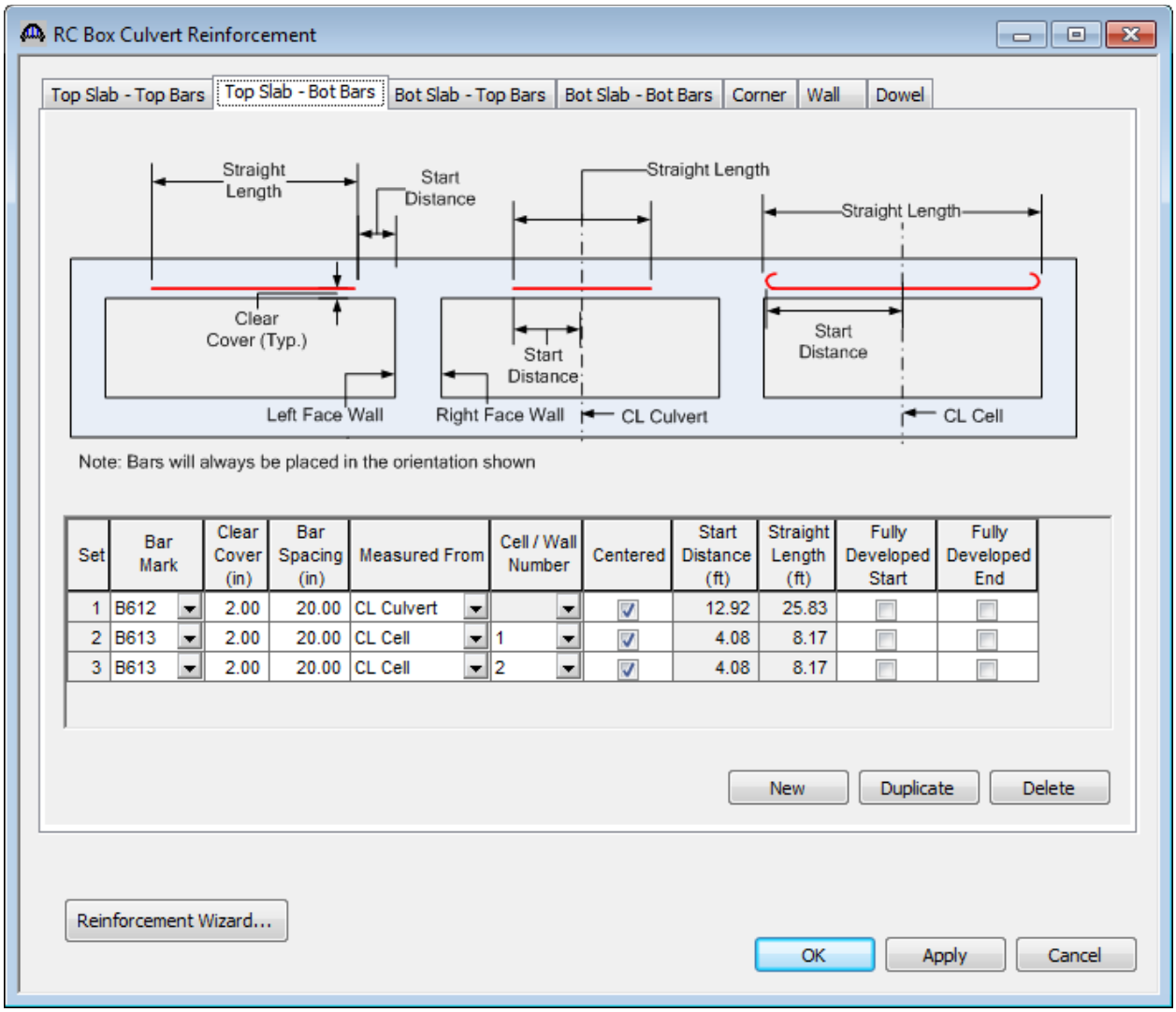


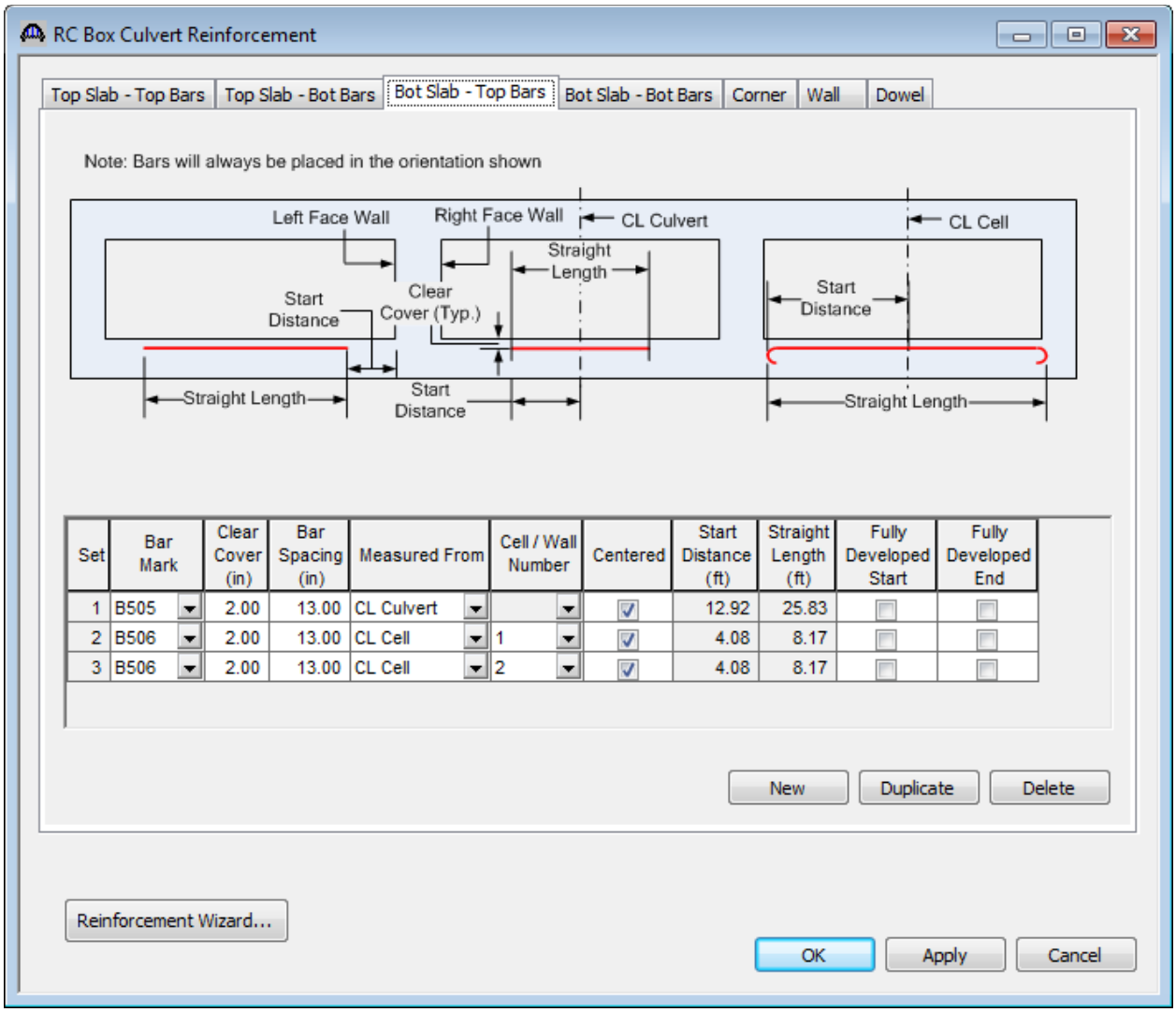
Double-click on RC Box Culvert Loads in the tree. Enter the culvert loads for Culvert Seg 1 as shown below. Click Ok to save the data to memory and close the window.

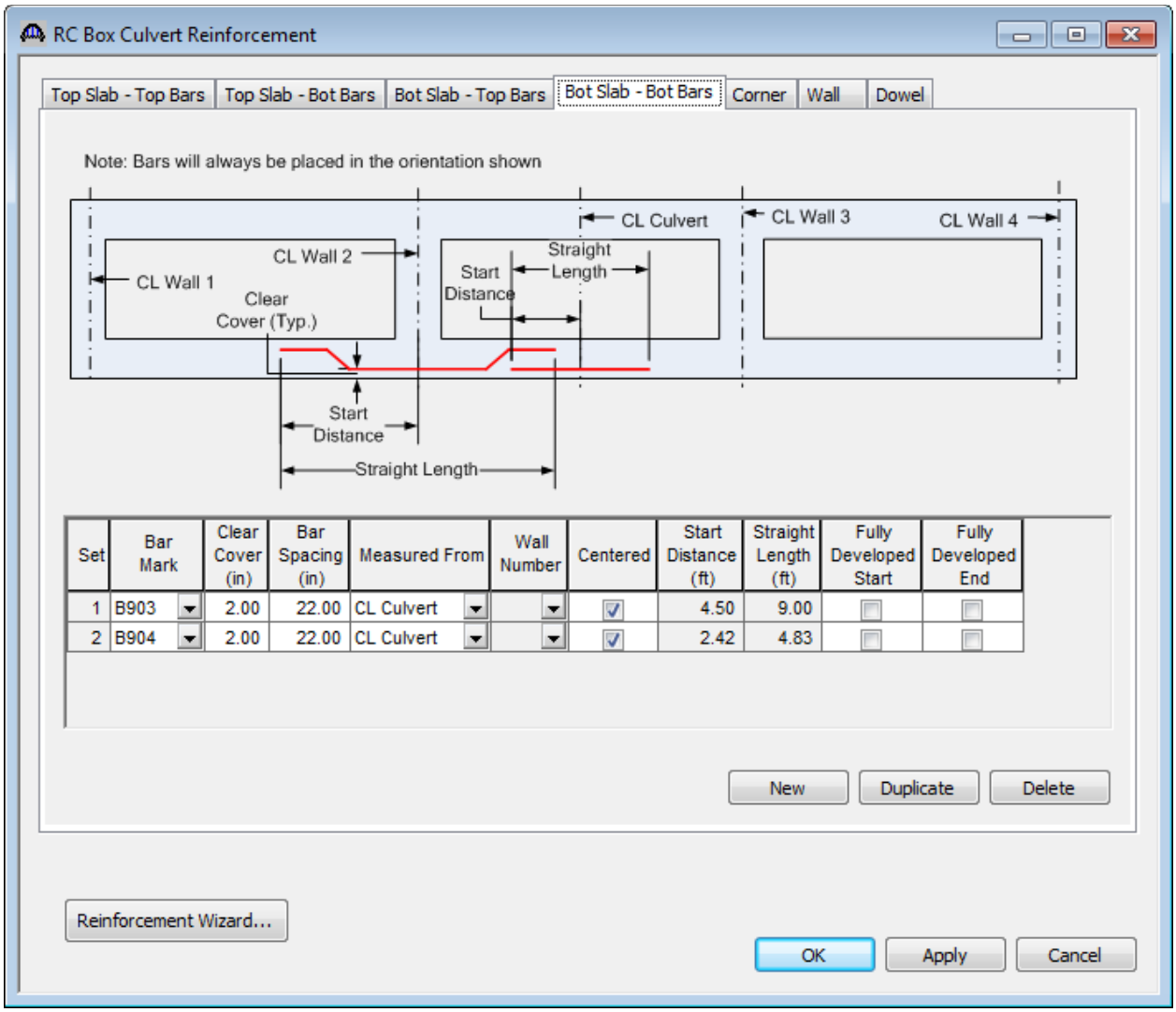


Double-click on RC Box Culvert Reinforcement in the tree. Enter the reinforcement data as shown below for each location. Click Ok to save the data to memory and close the window.



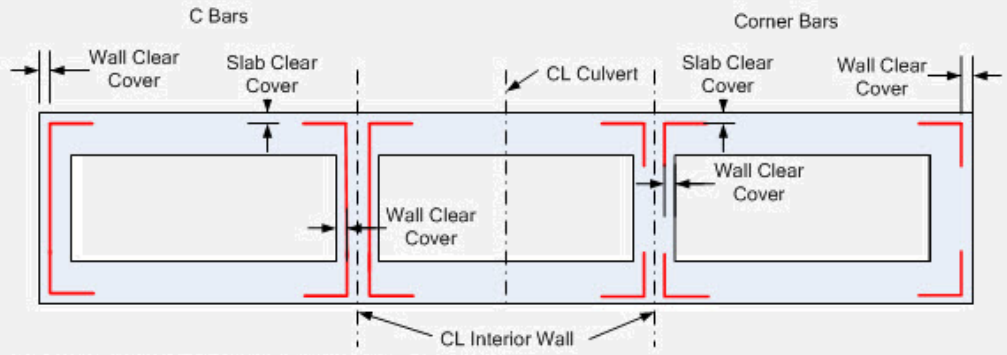

RC Box Culvert Reinforcement
Top Slab - Top Bars
Top Slab - Bot Bars
Bot Slab - Top Bars
Bot Slab - Bot Bars
Corner
Wall
Dowel
Straight Length
Start Distance
Straight Length
Straight Length
Clear Cover (Typ.)
Start Distance
Start Distance
Left Face Wall
Right Face Wall
CL Culvert
CL Cell
Note: Bars will always be placed in the orientation shown
Set
Bar Mark
Clear Cover (in)
Bar Spacing (in)
Measured From
Cell / Wall Number
Centered
Start Distance (ft)
Straight Length (ft)
Fully Developed Start
Fully Developed End
1 B612 2.00 20.00 CL Culvert 12.92 25.83
2 B613 2.00 20.00 CL Cell 1 4.08 8.17
3 B613 2.00 20.00 CL Cell 2 4.08 8.17
New
Duplicate
Delete
Reinforcement Wizard...
OK
Apply
Cancel


RC Box Culvert Reinforcement
Top Slab - Top Bars
Top Slab - Bot Bars
Bot Slab - Top Bars
Bot Slab - Bot Bars
Corner
Wall
Dowel
Note: Bars will always be placed in the orientation shown
Left Face Wall
Right Face Wall
CL Culvert
CL Cell
Straight Length
Start Distance
Clear Cover (Typ.)
Start Distance
Straight Length
Start Distance
Straight Length
Set
Bar Mark
Clear Cover (in)
Bar Spacing (in)
Measured From
Cell / Wall Number
Centered
Start Distance (ft)
Straight Length (ft)
Fully Developed Start
Fully Developed End
1 B505 2.00 13.00 CL Culvert 12.92 25.83
2 B506 2.00 13.00 CL Cell 1 4.08 8.17
3 B506 2.00 13.00 CL Cell 2 4.08 8.17
New
Duplicate
Delete
Reinforcement Wizard...
OK
Apply
Cancel


RC Box Culvert Reinforcement
Top Slab - Top Bars
Top Slab - Bot Bars
Bot Slab - Top Bars
Bot Slab - Bot Bars
Corner
Wall
Dowel
Note: Bars will always be placed in the orientation shown
CL Culvert
CL Wall 3
CL Wall 4
CL Wall 2
CL Wall 1
Clear
Cover (Typ.)
Straight
Length
Start
Distance
Start
Distance
Straight Length
Set
Bar Mark
Clear Cover (in)
Bar Spacing (in)
Measured From
Wall Number
Centered
Start Distance (ft)
Straight Length (ft)
Fully Developed Start
Fully Developed End
1 B903 2.00 22.00 CL Culvert 4.50 9.00
2 B904 2.00 22.00 CL Culvert 2.42 4.83
New
Duplicate
Delete
Reinforcement Wizard...
OK
Apply
Cancel

RC Box Culvert Reinforcement

Top Slab - Top Bars | Top Slab - Bot Bars | Bot Slab - Top Bars | Bot Slab - Bot Bars | Corner | Wall | Dowel



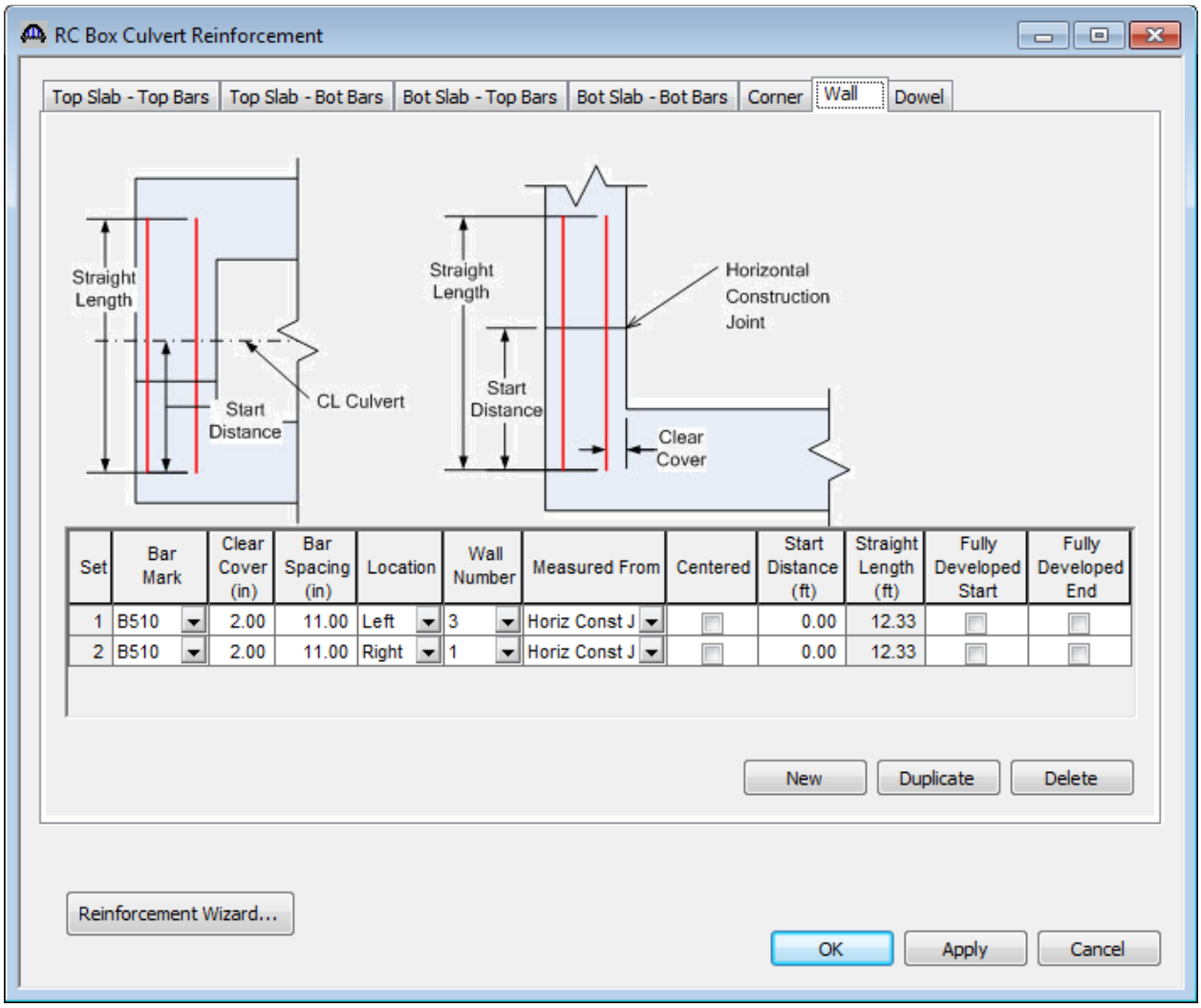
Note: Bars will always be placed in the orientation shown

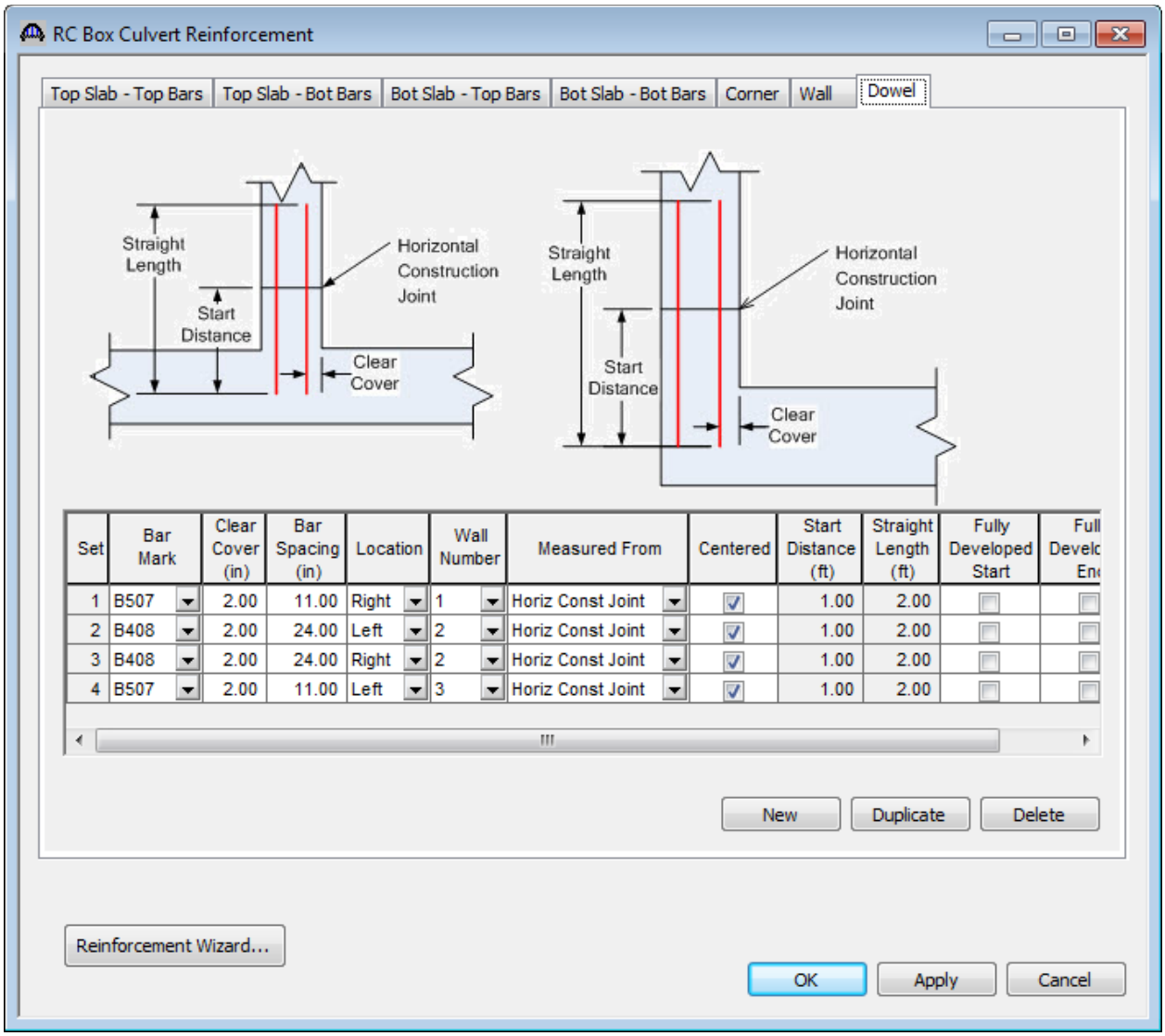
Set	Bar Mark	Wall Clear Cover (in)	Slab Clear Cover (in)	Bar Spacing (in)	Location	Wall Number	Fully Developed Vert	Fully Developed Horz
1	B801	2.00	2.00	16.00	Top Left		☐	☐
2	B801	2.00	3.00	16.00	Bottom Left		☐	☐
3	B801	2.00	2.00	16.00	Top Right		☐	☐
4	B801	2.00	3.00	16.00	Bottom Right		☐	☐
5	B411	2.00	0.00	24.00	Wall Top Left	2	☐	☐
6	B411	2.00	0.00	24.00	Wall Top Right	2	☐	☐
7	B802	2.00	3.00	16.00	Top Left		☐	☐
8	B802	2.00	3.00	16.00	Bottom Left		☐	☐
9	B802	2.00	3.00	16.00	Top Right		☐	☐
10	B802	2.00	3.00	16.00	Bottom Right		☐	☐

New | Duplicate | Delete

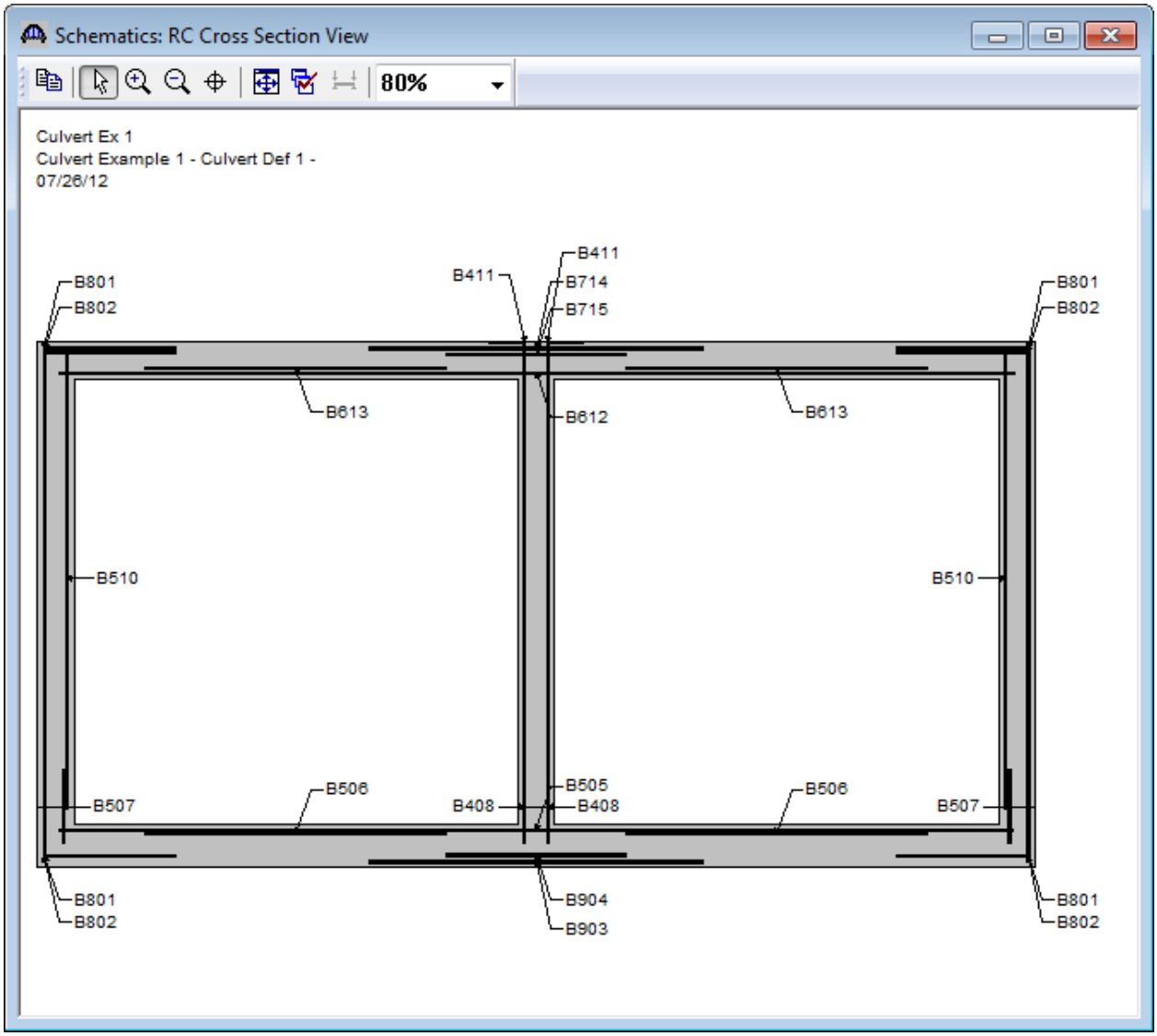
Reinforcement Wizard...

OK | Apply | Cancel


RC Box Culvert Reinforcement
Top Slab - Top Bars
Top Slab - Bot Bars
Bot Slab - Top Bars
Bot Slab - Bot Bars
Corner
Wall
Dowel
Straight Length
Start Distance
CL Culvert
Straight Length
Start Distance
Horizontal Construction Joint
Clear Cover
Set
Bar Mark
Clear Cover (in)
Bar Spacing (in)
Location
Wall Number
Measured From
Centered
Start Distance (ft)
Straight Length (ft)
Fully Developed Start
Fully Developed End
1 B510 2.00 11.00 Left 3 Horiz Const J 0.00 12.33
2 B510 2.00 11.00 Right 1 Horiz Const J 0.00 12.33
New
Duplicate
Delete
Reinforcement Wizard...
OK
Apply
Cancel


RC Box Culvert Reinforcement
Top Slab - Top Bars
Top Slab - Bot Bars
Bot Slab - Top Bars
Bot Slab - Bot Bars
Corner
Wall
Dowel
Straight Length
Start Distance
Horizontal Construction Joint
Clear Cover
Straight Length
Start Distance
Horizontal Construction Joint
Clear Cover
Set
Bar Mark
Clear Cover (in)
Bar Spacing (in)
Location
Wall Number
Measured From
Centered
Start Distance (ft)
Straight Length (ft)
Fully Developed Start
1 B507 2.00 11.00 Right 1 Horiz Const Joint 1.00 2.00
2 B408 2.00 24.00 Left 2 Horiz Const Joint 1.00 2.00
3 B408 2.00 24.00 Right 2 Horiz Const Joint 1.00 2.00
4 B507 2.00 11.00 Left 3 Horiz Const Joint 1.00 2.00
New
Duplicate
Delete
Reinforcement Wizard...
OK
Apply
Cancel

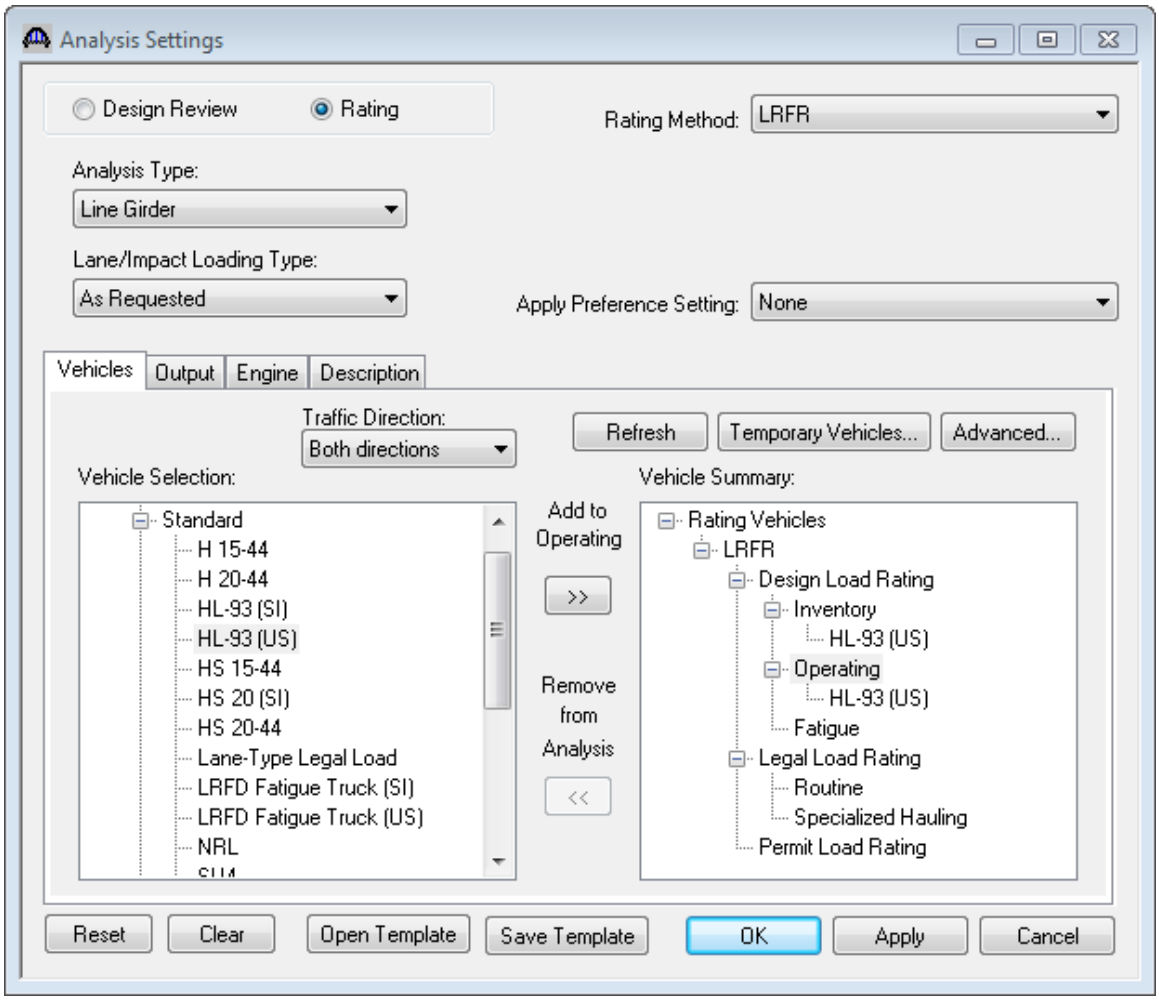
Select Bridge | Schematic to review the reinforcement data.



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

Perform AASHTO Culvert LRFR analysis and review results

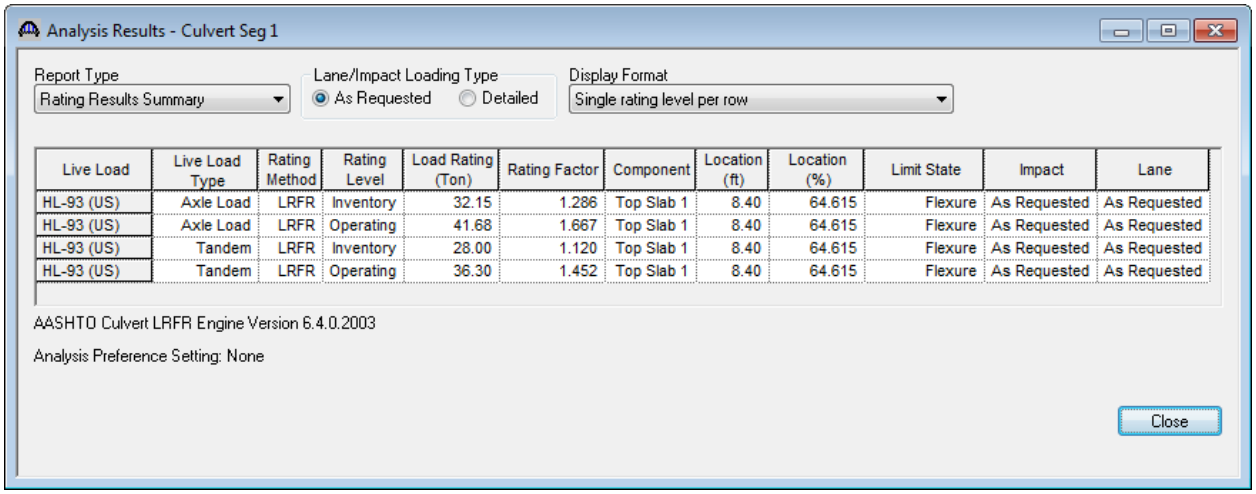
To perform LRFR Design Load Rating, open the Analysis Settings window. Select LRFR as the Rating Method and specify the HL-93 (US) vehicle for LRFR Inventory and Operating Design Load Rating.



Click Ok to save the analysis settings to memory and close the window.

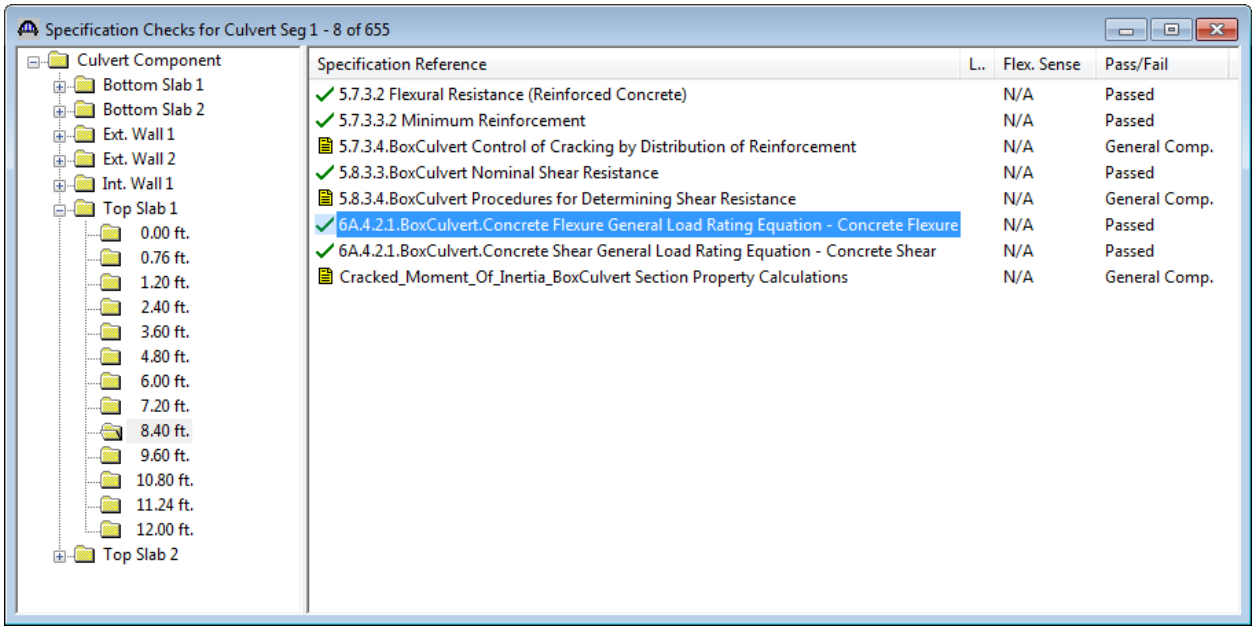
Select Culvert Seg 1 in the tree. Select Bridge | Analyze to start the rating process. Click Ok to close the Analysis Progress window after the analysis is completed.

Select Bridge | Tabular Report to open the Analysis Results window.

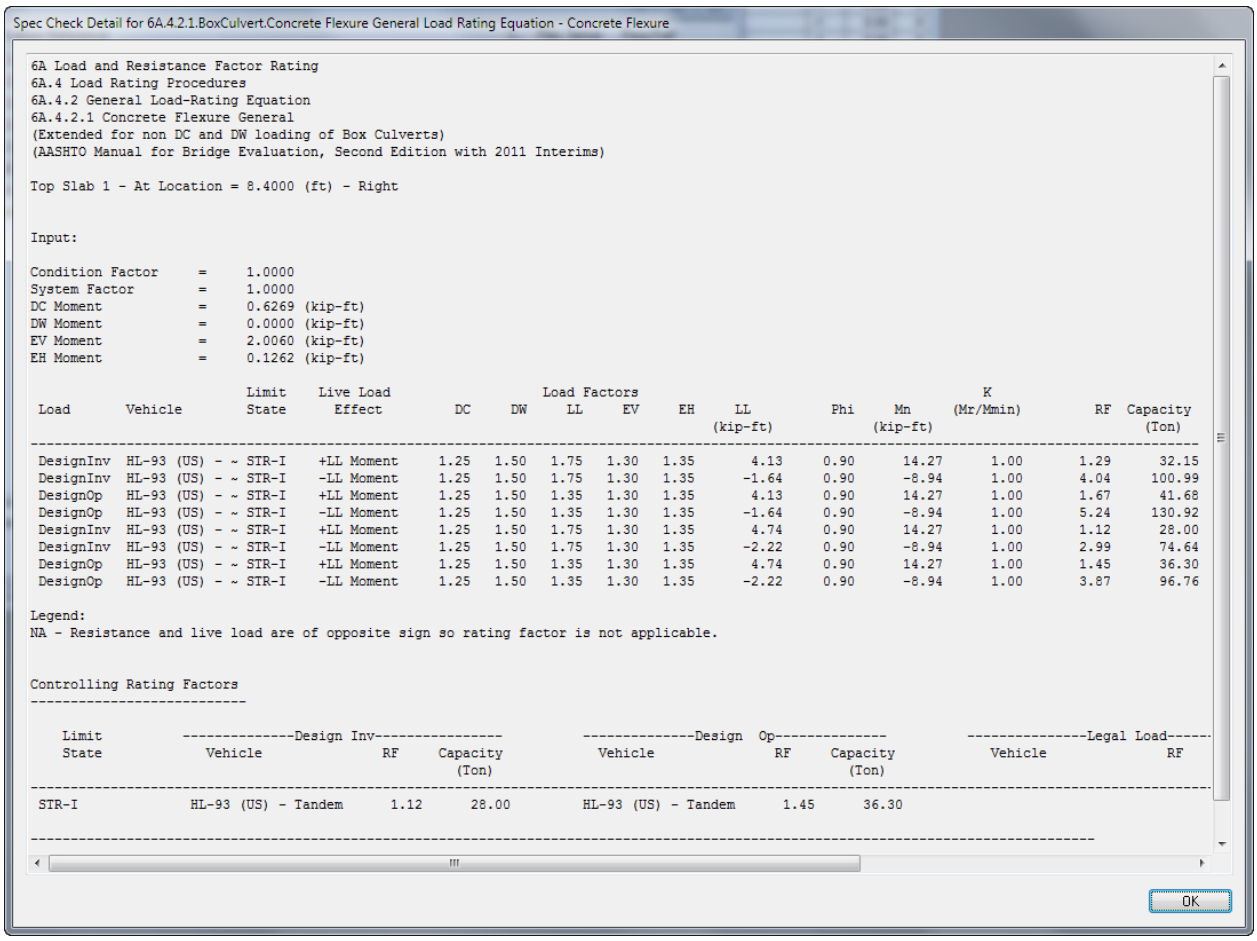


Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Component	Location (ft)	Location (%)	Limit State	Impact	Lane
HL-93 (US)	Axle Load	LRFR	Inventory	32.15	1.286	Top Slab 1	8.40	64.615	Flexure	As Requested	As Requested
HL-93 (US)	Axle Load	LRFR	Operating	41.68	1.667	Top Slab 1	8.40	64.615	Flexure	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Inventory	28.00	1.120	Top Slab 1	8.40	64.615	Flexure	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Operating	36.30	1.452	Top Slab 1	8.40	64.615	Flexure	As Requested	As Requested

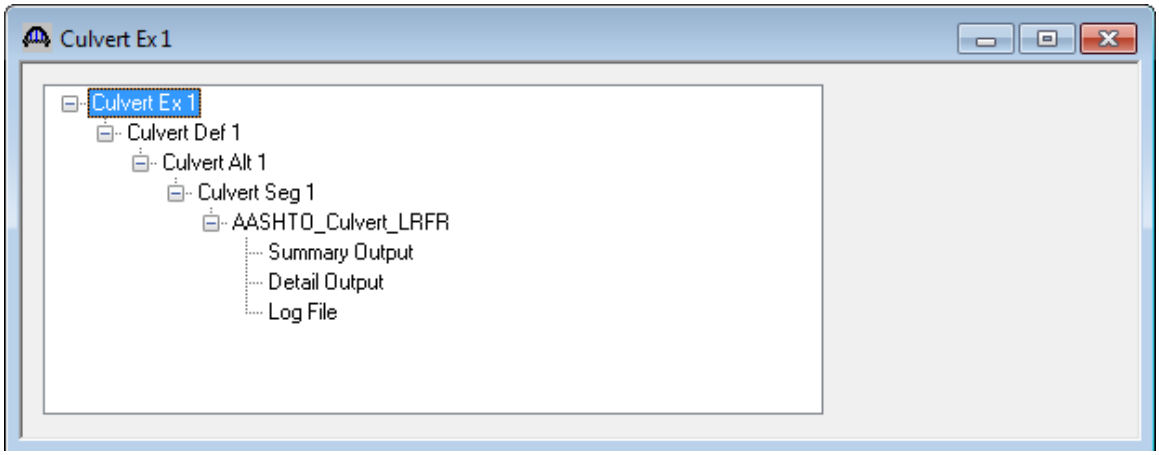
To review detailed rating results at the controlling location, select Bridge | Specification Checks to open the Specification window. Expand the tree for Top Slab 1 and select the 8.40 ft. folder.



Double-click on the 6A.4.2.1 Concrete Flexure specification reference to open the Spec Check Detail window.

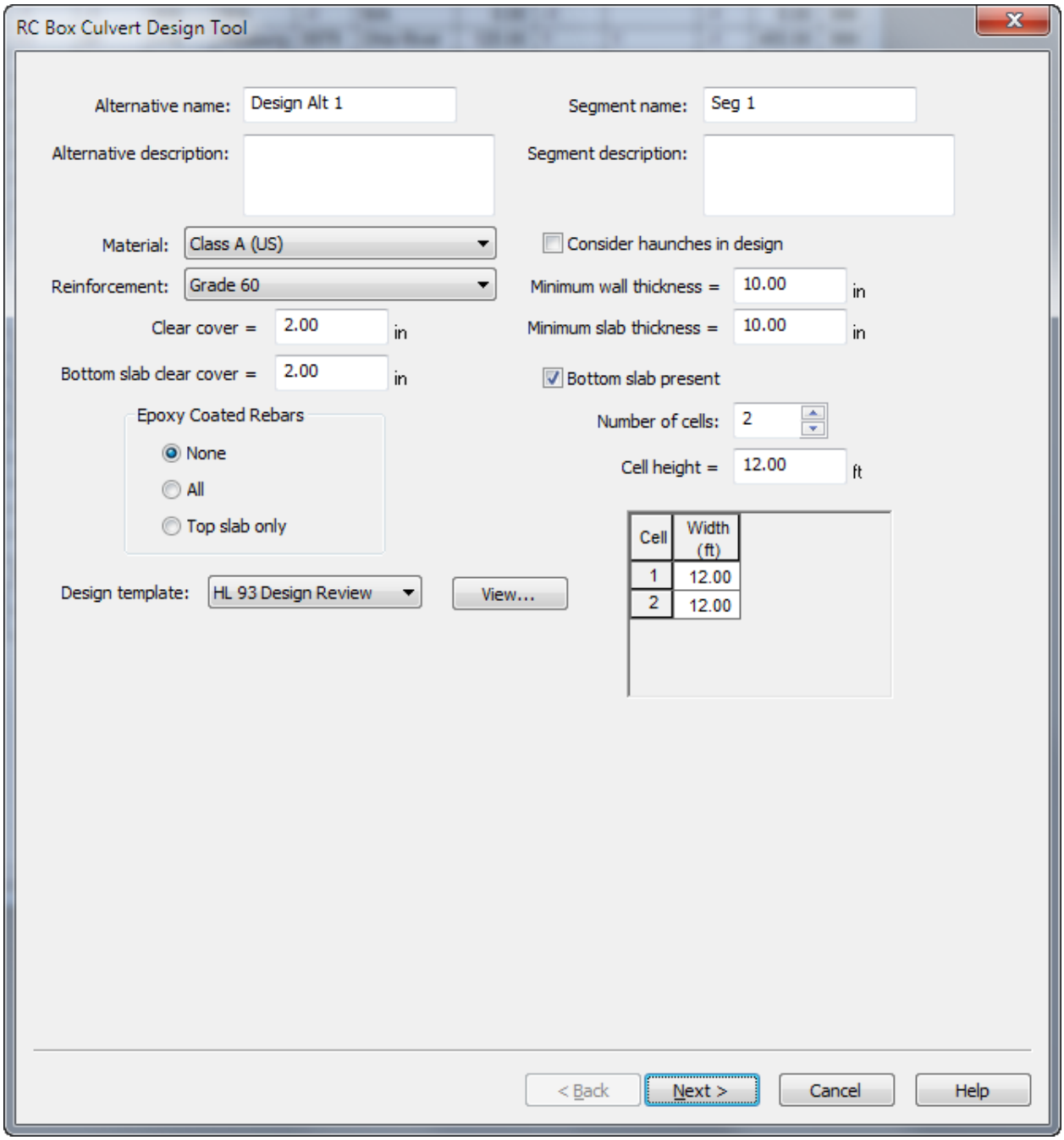


To review engine outputs, select Bridge | Output. Double-click on the Summary or Detail Output will open the engine output file in a separate window.

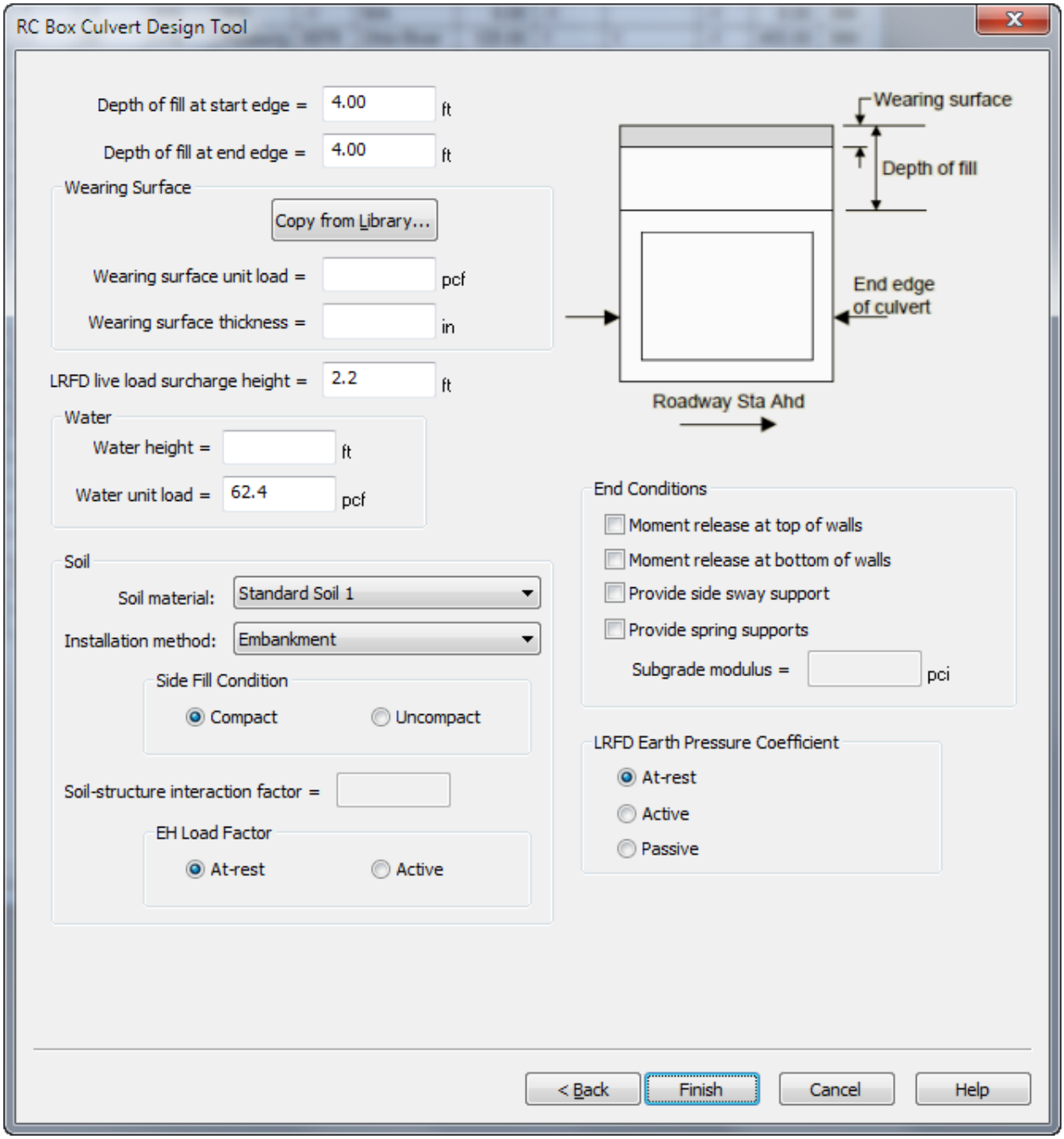


Culvert Design Tool

Select the CULVERT ALTERNATIVES folder in the Bridge Workspace tree. Select Bridge | Curvert Design Tool to open the RC Box Culvert Design Tool. Enter the data as shown below.

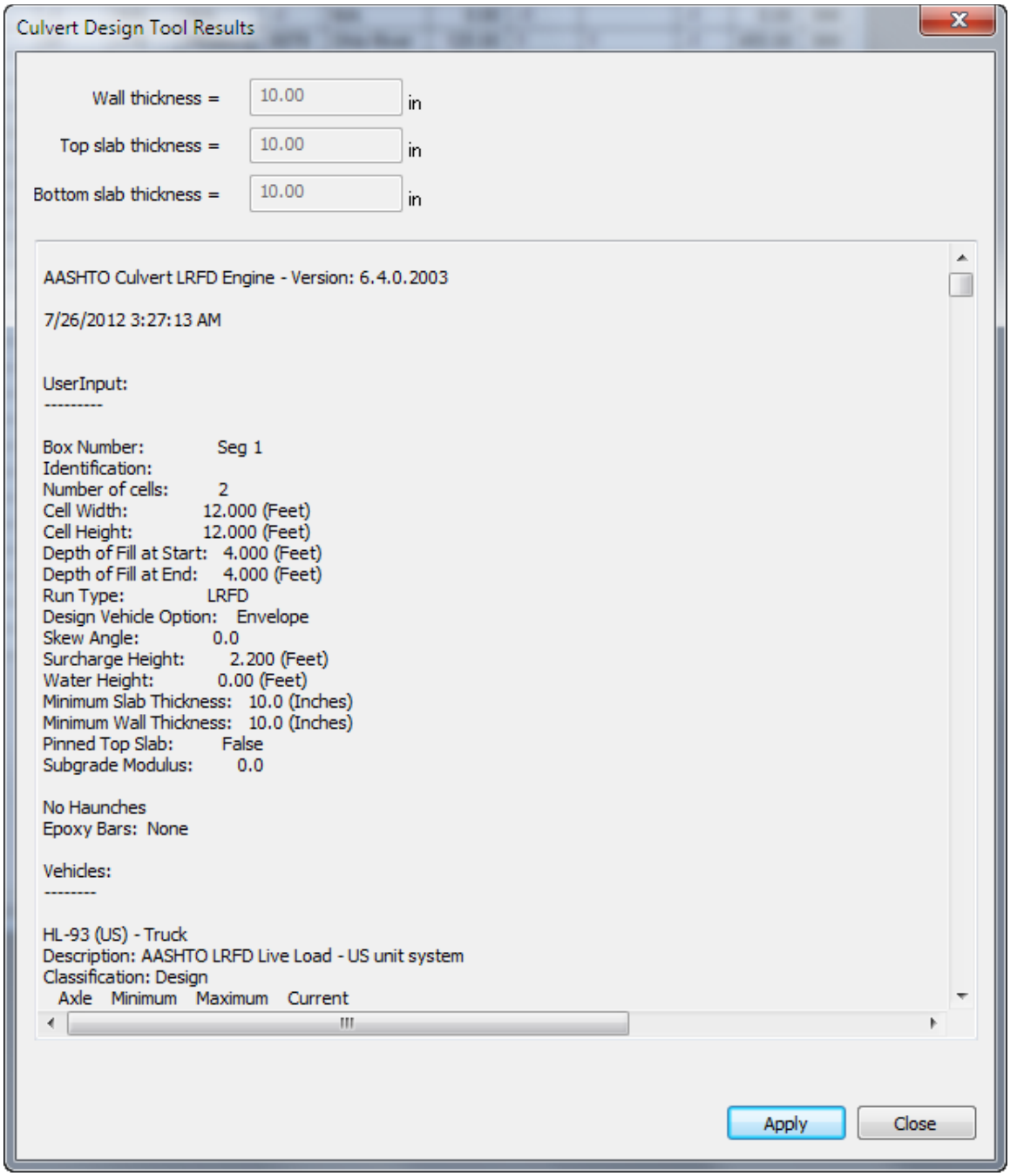


Click Next and enter the data as shown below.

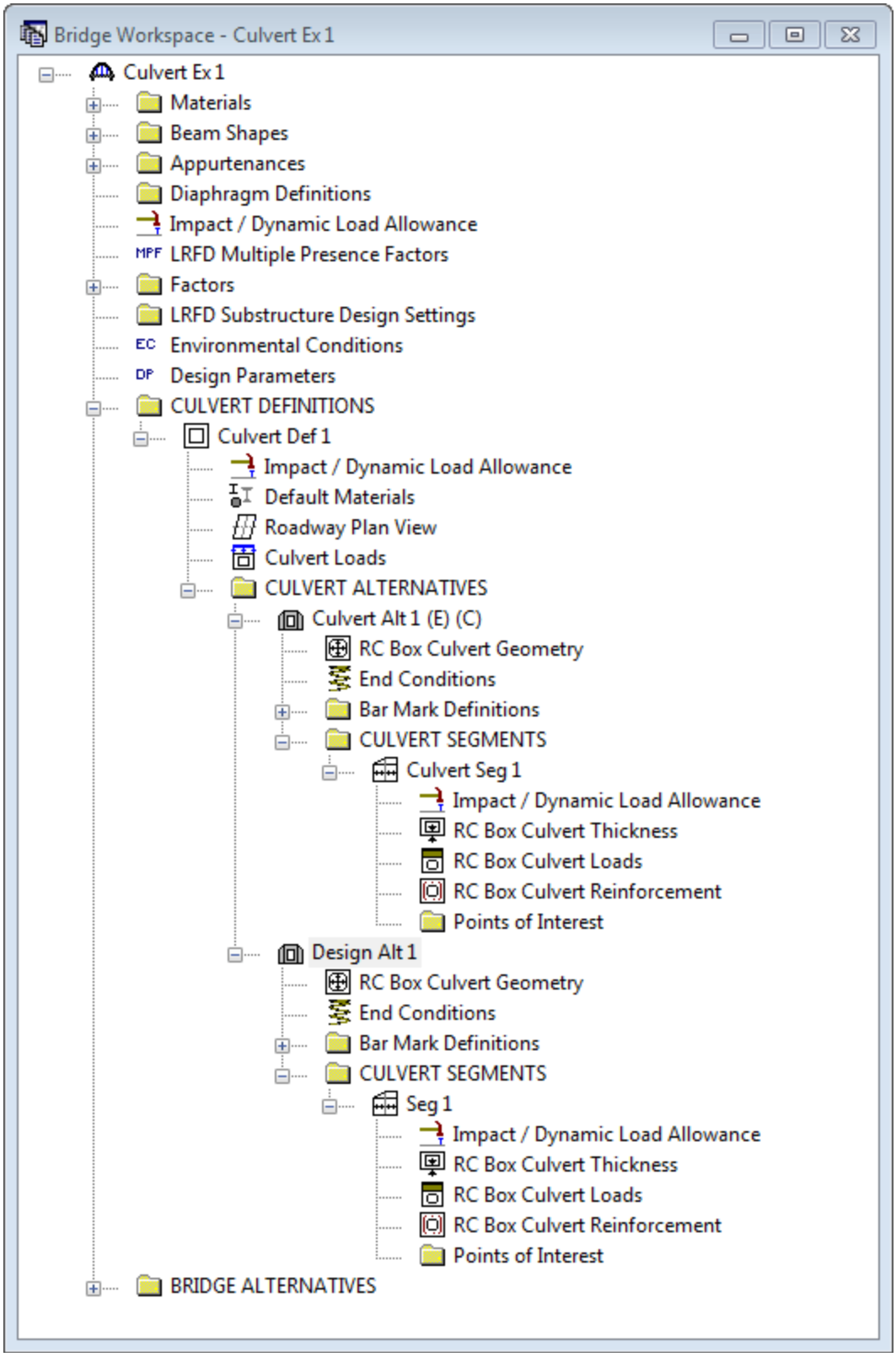
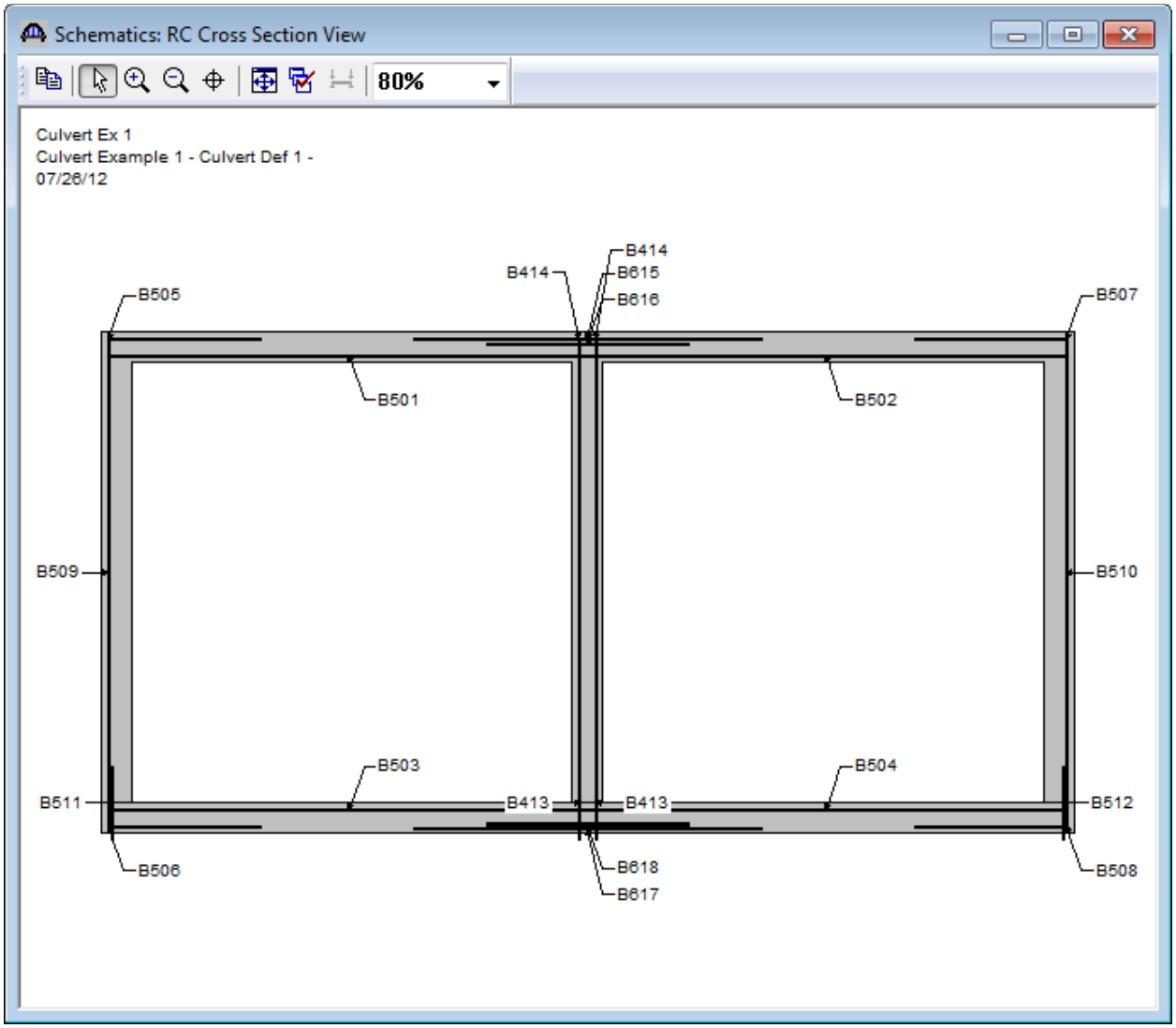


Click Finish to start the design process. Click Ok to close the RC Box Culvert Design Tool Progress window after the design is completed.

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



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



Select Design Alt 1 RC Box Culvert Reinforcement in the tree. Select Bridge | Schematic to review the reinforcement data.