SECTION 14
CONCRETE BOX CULVERT

14.1 INTRODUCTION TO RATING CONCRETE BOX CULVERTS

This section covers the rating of cast-in-place (CIP) concrete and pre- cast box culverts. All concrete box culverts are to be rated using the policies and guidelines of the Bridge Rating Manual, Section 1 and Subsections 14-2 and 14-3.

The rating of other culverts is discussed in Section 14A.

When there are no plans available for the concrete box culverts being rated, the requirements in Subsection 1.7, and 14.2 (III) shall be used.

For CBC extension projects, the rating process shall follow the CDOT Bridge Rating Manual, Section 1-17.

The types of rigid culverts covered by this section are:

CBC - Concrete Box Culvert
PCBC - Concrete Box Culvert, Pre-Cast

The types of culverts not covered by this section are:

AAC - Aluminum Arch Culvert
CAC - Concrete Arch Culvert
RCPC - Reinforced Concrete Pipe Culvert
RAC - Rubble Arch Culvert
SAC - Steel Arch Culvert
TBC - Timber Box Culvert
TTC - Timber Culvert
CMP - Corrugated Metal Pipe

14.2 POLICIES AND GUIDELINES FOR RATING CONCRETE BOX CULVERTS

14.2.1 General

A. All existing ASD & LFD CBCs shall be rated or rerated with LFR or LRFR methods, All LRFD CBCs shall be rated with LRFR method

B. All major concrete box culverts (i.e. length greater than 20' between inside faces of outside walls) shall be rated by the AASHTOWARE BrR program. The Rater shall verify with the Staff Bridge Rating Coordinator that the version number of the program being used is identical to CDOT'S version number. Data files created using a lower, or higher version of the program shall be rejected, except if approved by the Bridge Rating Engineer. Programs other than AASHTOWARE BrR must be approved in advance by the Bridge Rating Engineer. If CDOT standard plans (i.e. M-601-1, M-601-2 and M-601-3) are used in the design, the BrR xml files for each type and size of CBC are available and can be provided by Staff Bridge if requested.

C. Inventory and operating Design Load Rating levels shall be performed for the HS20-44 loading when LFR method is used and the HL93 loading when LRFR method is used. Also, the Legal Load Rating and Permit Load Rating levels shall comply with BRM subsection 1.2.

> Note: For LFR live load distribution factors refer to "The AASHTO Standard Specifications", "The AASHTO Manual for Bridge Evaluation", and the "AASHTO LRFD/LRFR/LFD Culvert Method of Solution Manual."
>
> For LRFR live load distribution factors refer to "The AASHTO LRFD Specifications", "The AASHTO Manual for Bridge Evaluation", the "AASHTO LRFD/LRFR/LFD Culvert Method of Solution Manual."

D. When the depth of the fill exceeds 8.0 feet and exceeds the clear span for a single-cell culvert or exceeds the distance between interior faces of the outer walls for a multiple-cell culvert, live load analysis is not required. For how to report the load ratings, see the BRM subsection 1.14, but an xml file still required. The controlling depth of fill shall be recorded on the Rating Summary Sheet with the notation "live load is negligible".

14.2.2 Calculations

A. A set of calculations, separate from computer output, shall be submitted with each rating package. These calculations shall include derivations for dead loads and any other calculations or assumptions used for rating.

B. Dead Loads

1. The final sum of all the individual weight components for dead load calculations may be rounded up to the next 5 pounds.
2. Dead loads include fill, curbs, sidewalks, railing, etc.

C. Use the minimum design yield strength value Fy and the minimum compressive strength of concrete F'c from plans if not shown refer to Section 1.5.

14.2.3 Guidelines for using Engineering Judgement / Visual Rating

When performing visual ratings, either the Rating Engineer or the Rating Checker shall be a Colorado Registered Professional Engineer.

The following provides guidelines for visual ratings:

Step 1: Pull the structure folder.

Step 2: Look for plans in the folder that are sufficient to perform the rating analysis. If the folder has plans that completely detail the reinforcement as well as notes that call out a specific design fill height together with all corresponding sheets from the M-Standard (if the culvert was designed using the CDOT M-Standard); the structure shall be rated using the AASHTOWARE BrR (formerly Virtis, preferred software), Brass Culvert or other approved program.

Step 3: Look at the fill height, item 66T on the SIA Sheet, and inspection sketch. Live load contribution through fill will be assumed as per the Bridge Rating Manual section 14.2.1(D).

Step 4: Look at the condition state, item 62 on the SIA sheet. In general NBI condition rating of 6 and above will not require a reduction in live load carrying capacity.

Step 5: Review the inspection notes and photos. Look for signs of live load deterioration such as:

- Essential repairs with any load restrictions.
- Transverse cracking that is breaking up, delaminating or spalling. Transverse cracking is cracking normal to the culvert span. These cracks could indicate a reduced shear or flexural capacity.
- Guidance on crack width will be taken from the Pontis coding guide. The Pontis coding guides states a crack width 3/32” or less will not significantly reduce strength. Cracks greater than 3/32” will warrant further analysis. Cracking longitudinal to the culvert span is typically due to shrinkage and differential settlement. Cracking longitudinal to the culvert span will not warrant further investigation.
- Pending essential repairs that affect the structural integrity.
- Exposed rebar located in high moment and shear regions.
- Spalling not caused by debris impact.
- Spalling caused by debris impact in a high shear or high moment region.
- Excessive deflection noted in top/bottom slab and walls during inspection.
- Essential repairs with severe scour and settlement.

If clarification of inspection notes is necessary, the Rater or Rating Checker shall meet with the inspector to clear up any questions.

Step 6: If no live load carrying capacity reduction is warranted, fill out and sign the rating summary sheet. The numerical value will be based on section 1.7.2(B).
The following notes should appear on the rating summary sheet.

- Total structure length (Inside face to inside face of exterior walls).
- Fill height (shown in tenth of feet).
- Plans availability (yes, no or partial).

- Describe any load induced damage (if none, state none).List any pending essential repairs (if none, state none).
- NBI condition state coding for Item 62.
- Describe any damage that has a direct effect on load rating capacity (if none, state none). Also note the inspection date the distress as first identified.
- Color Code assignment.
- When Fill Height controls live load rating, use this note “Live load is negligible per section 14-2 of the CDOT Bridge Rating Manual.”
- “Visually Rated” will be noted in the Comments section of the Rating Summary Sheet.

Step 7: If live load reduction is required based the criteria in Step 5, the rater shall assign a reduced load rating as described in the Step 6. The rater shall document a color code recommendation along with the fill height, location and magnitude of distress. For on-system structures, this documentation shall be submitted to the Staff Bridge Rating Unit. The Staff Bridge Rating Unit will coordinate a review panel. At a minimum, this review panel shall consist of the Staff Bridge Engineer, Staff Bridge Rating Engineer and Staff Bridge Inspection Engineer. This panel will make the final decision on any live load restrictions.

Step 8: Turn the structure folder and rating summary sheet over to the checker for review. The checker shall verify compliance with steps 2 through 6 above. If satisfactory and in agreement, the checker shall sign the summary sheet. If it is not satisfactory, the checker will send comments to the rater and find agreement prior to signing.

Step 9: The checker shall follow the CDOT Bridge Rating Archiving Policy Memo before submitting the rating package to the Bridge Rating Unit.
The foregoing applies to off-system structures except for the review panel in step 7, the color code in step 6 and step 9.

14.3 RATING REPORTING AND PACKAGING REQUIREMENTS

14.3.1 Rating Reporting / Package Requirements

A. A copy of the AASHTOWare BrR reinforcement schematic drawing showing the elevation and applied loads shall be included with the rating package.

B. The rater and checker shall complete the rating documentation (i.e. the rating QA checklist) as described in Section 1 of the Bridge Rating Manual. Any variation from the original design assumptions shall be added to the Rating Summary Sheet as applicable. The rating package requirements shall be per Section 1.13 of the Bridge Rating Manual and as amended here.

14.3.2 Consultant Requirements

A. Consultant designed projects – Before finalizing the rating package and when AASHTOWare BrR is used as the analysis tool, the Rater shall verify with the Staff Bridge that the version number of the program being used is identical to CDOT'S version number. Data files created using a lower, or higher version of the program shall be rejected, except if approved by the Bridge Rating Engineer.

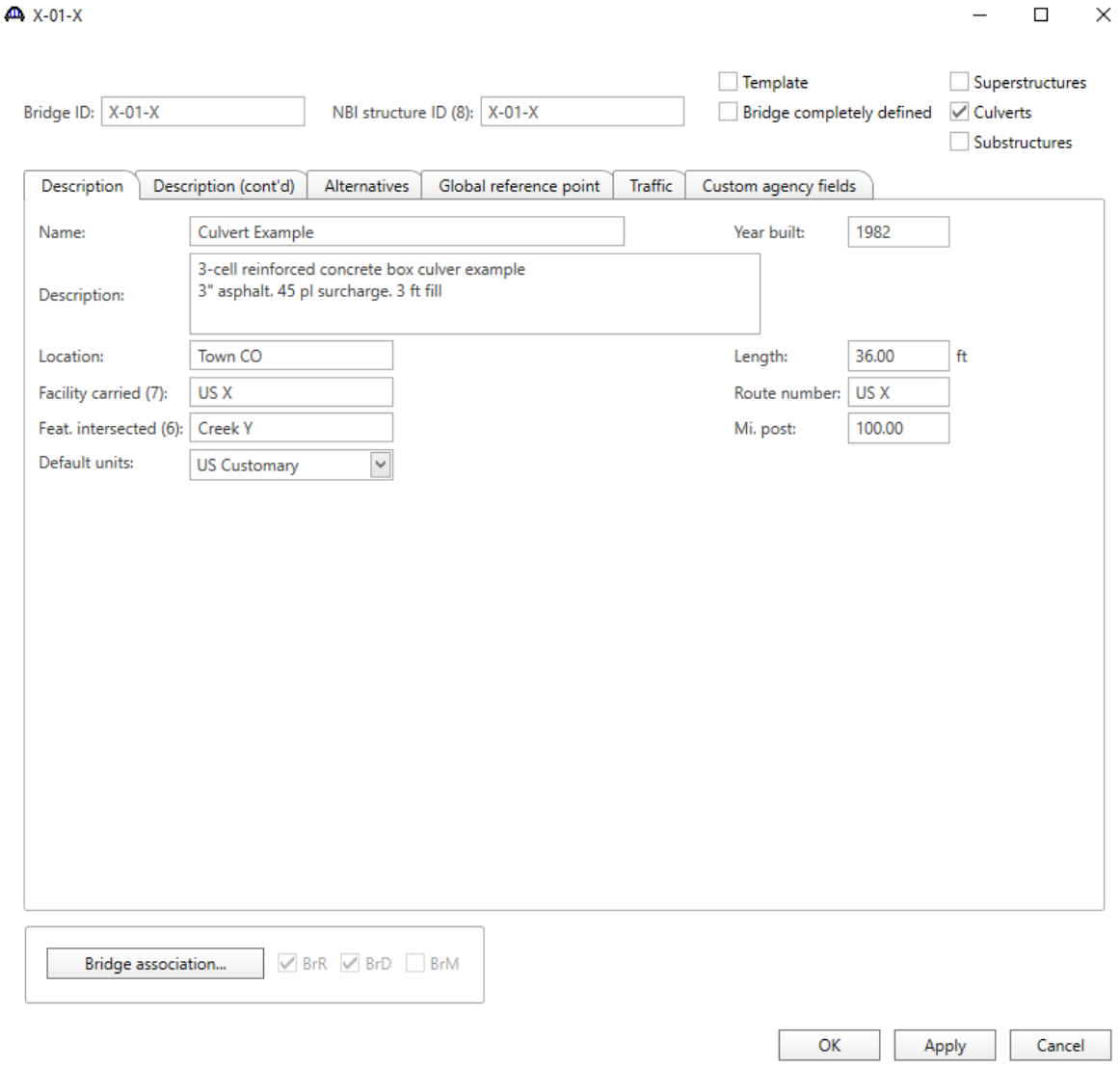
B. When the rating is finalized, the rater shall save the input files in ".xml" format. The file name shall include the structure number of the rated CBC (i.e., O-14-BY.xml). The rating package including input program file, Rating Summary Sheet and necessary computations in pdf shall be transmitted electronically to Staff Bridge for archiving.

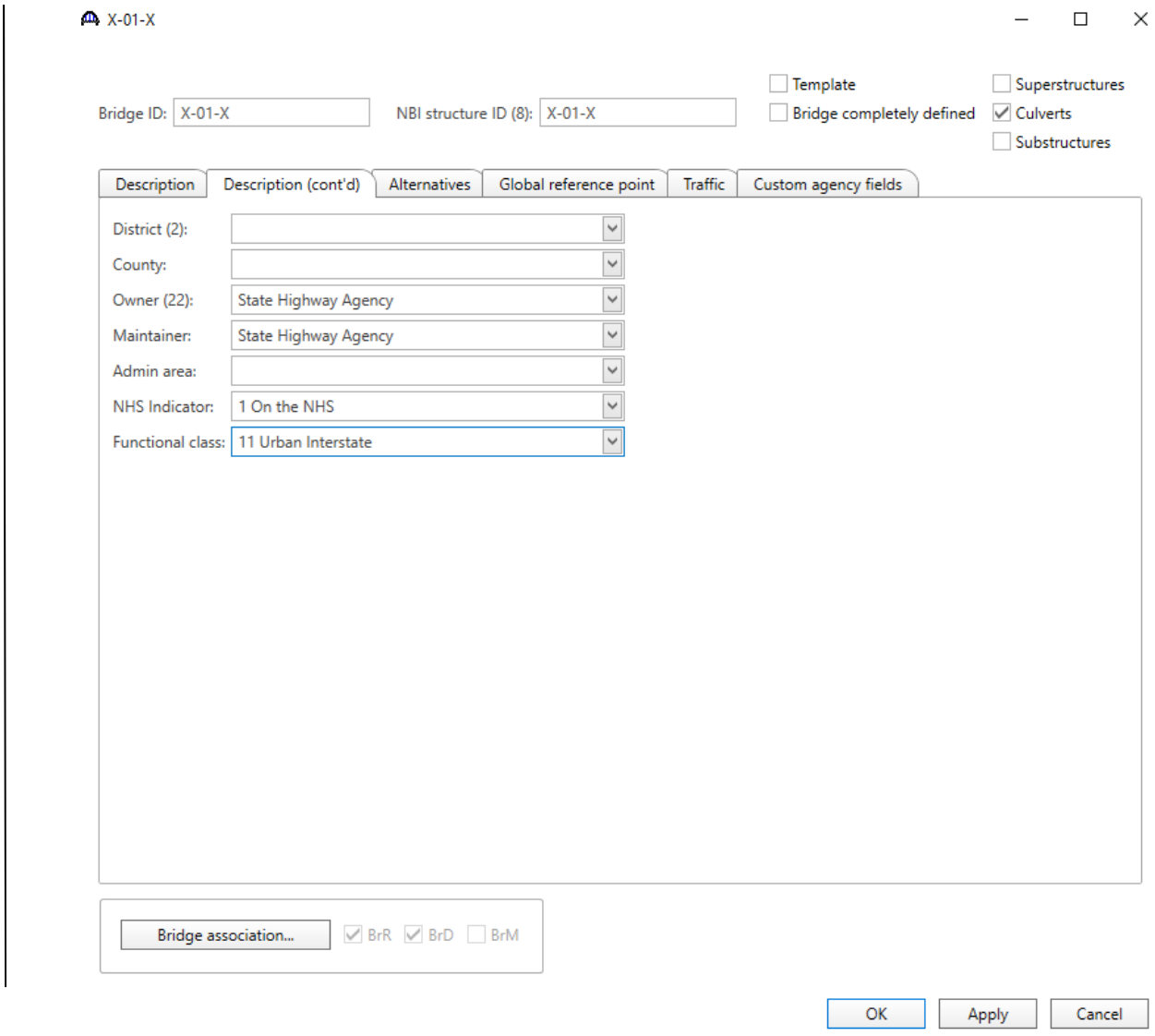
14.4 CONCRETE BOX CULVERT RATING EXAMPLES

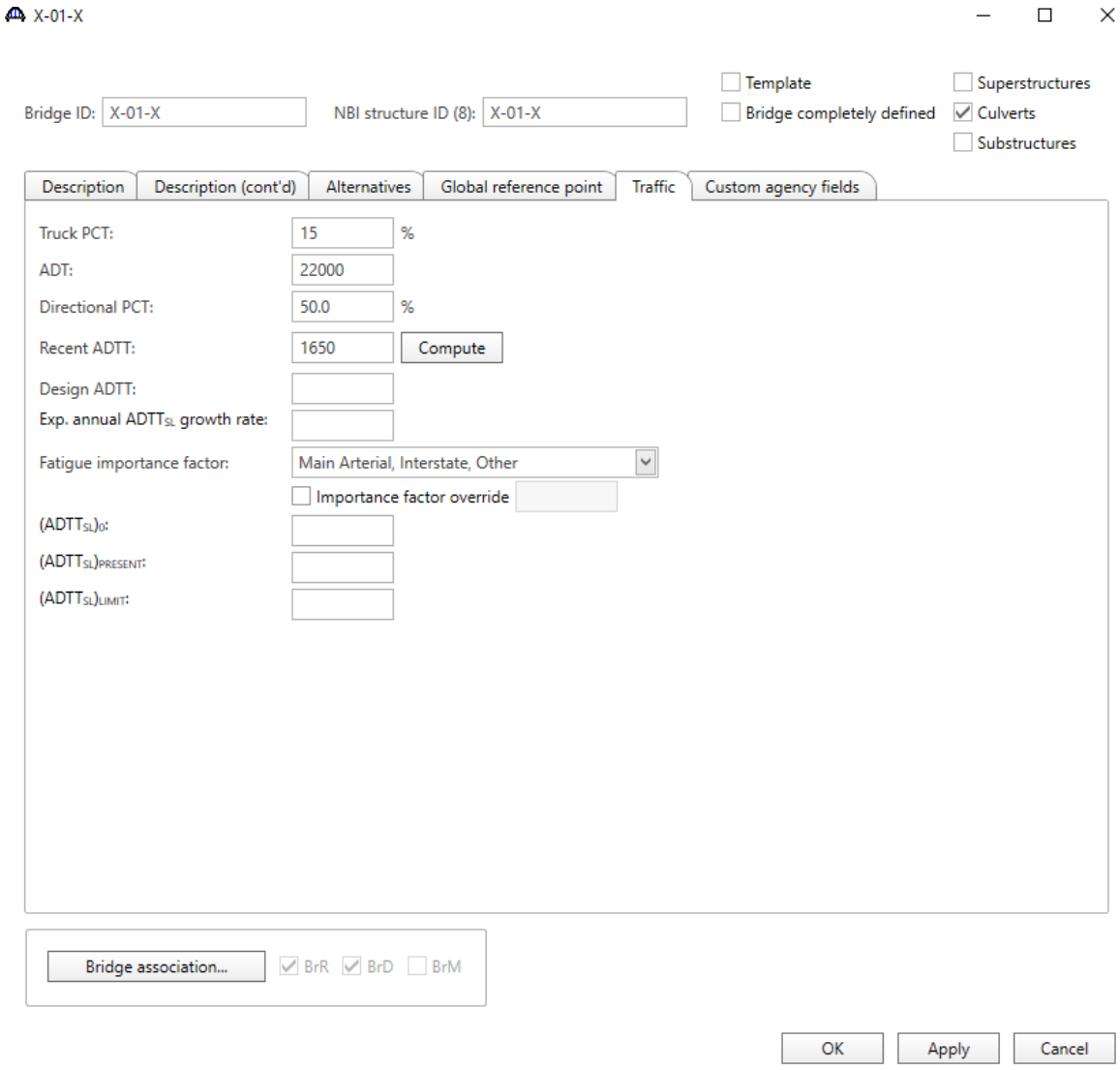
Two examples are presented in this section. First, Structure X-01-X is a 3-cell culvert with 3 feet of asphalt and fill. The structure has a 6 inch asphalt overlay. This structure is rated using a HS20-44 truck and lane live load, Colorado Permit Vehicle, Colorado Legal Type 3, 3S2, 3-2 vehicles, NRL, SU4 thru SU7 and EVs vehicles.
The second structure, X-02-X, is a single-cell culvert with a skew of 10° degrees. The culvert has 6 feet of fill. It also carries a 4 inch asphalt roadway. This structure is rated using a HL-93 truck and lane live load, Colorado Permit Vehicle, Colorado Legal Type 3, 3S2, 3-2 vehicles, NRL, SU4 thru SU7 and EVs vehicles.

14.4.1 AASHTOWare BrR Program - Version 7.2
Example 1 (LFR) – Structure No. X-01-X

From the Bridge Explorer, select File | New | New Bridge to create a new bridge and then enter the following description information.

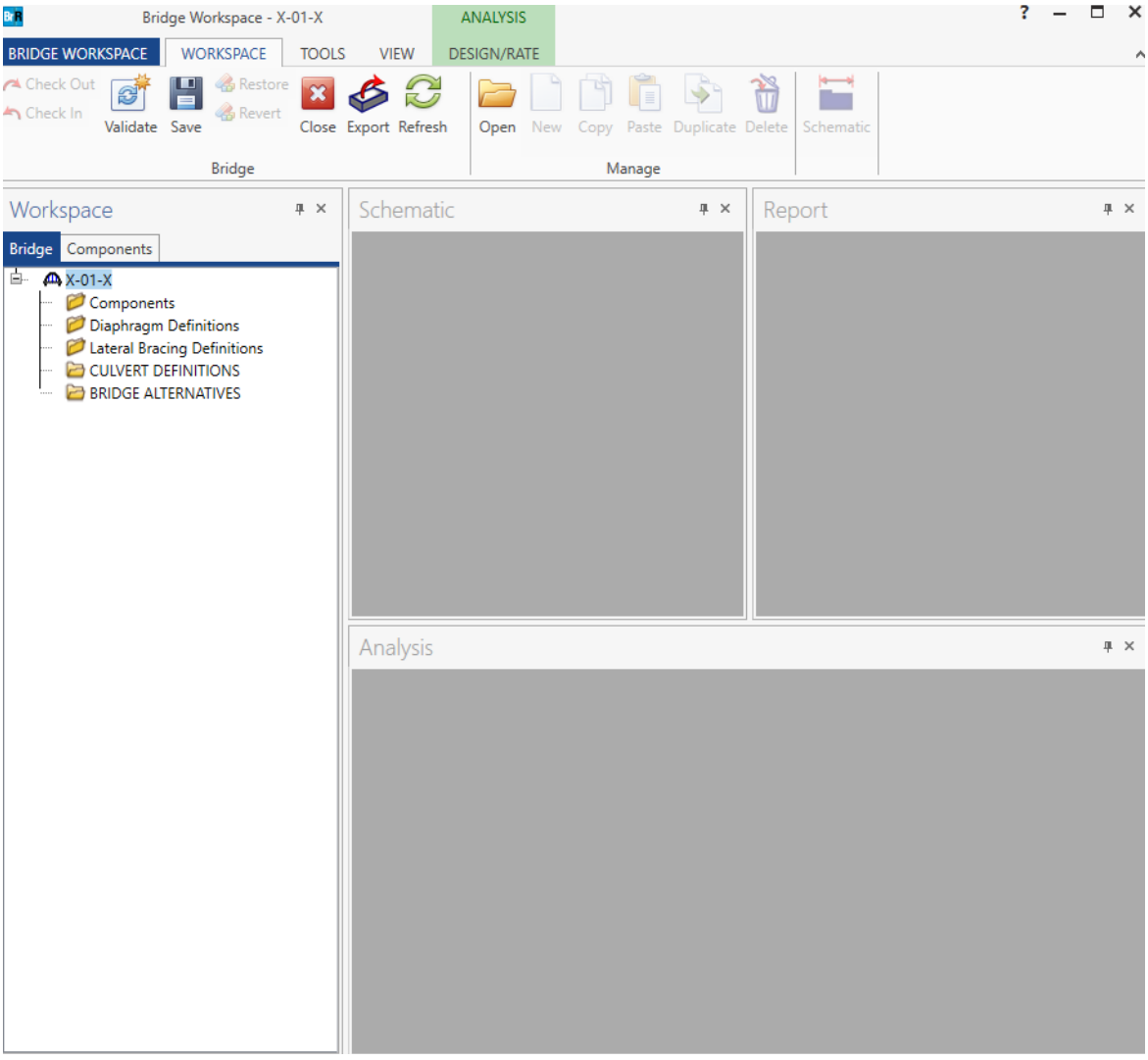



X-01-X
Bridge ID: X-01-X
NBI structure ID (8): X-01-X
Template
Bridge completely defined
Superstructures
Culverts
Substructures
Description
Description (cont'd)
Alternatives
Global reference point
Traffic
Custom agency fields
District (2):
County:
Owner (22): State Highway Agency
Maintainer: State Highway Agency
Admin area:
NHS Indicator: 1 On the NHS
Functional class: 11 Urban Interstate
Bridge association...
BrR
BrD
BrM
OK
Apply
Cancel

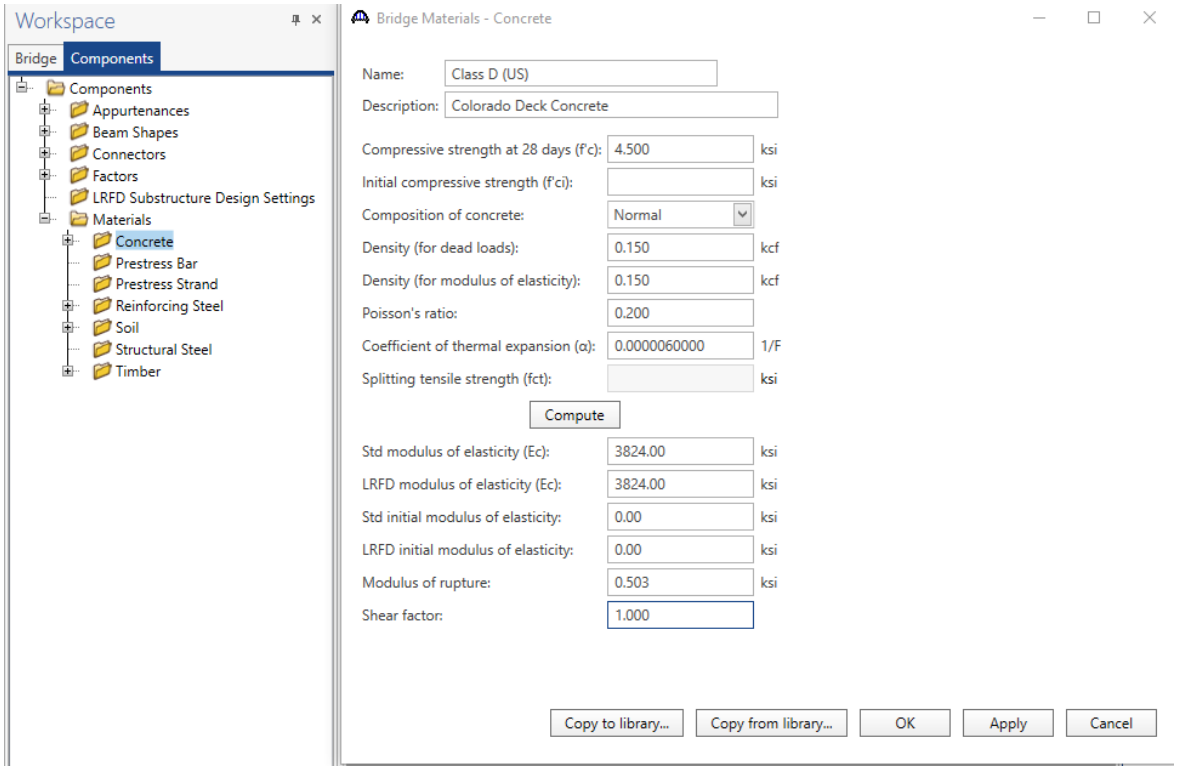


Close the window by clicking OK. This saves the data to memory and closes the window.

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

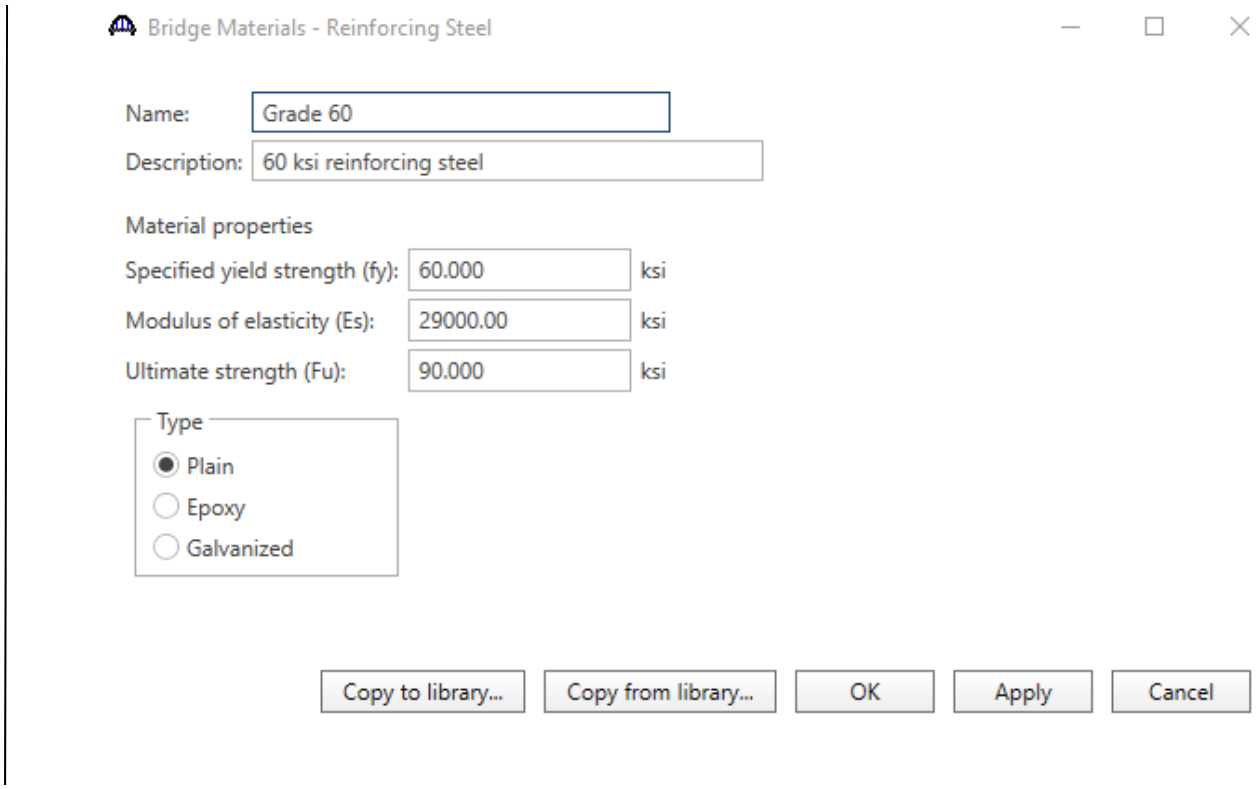


To enter the materials for the culvert, click on the Components and expand the tree for Materials. Double-click on the Concrete folder to create a new concrete material. Enter the following values.

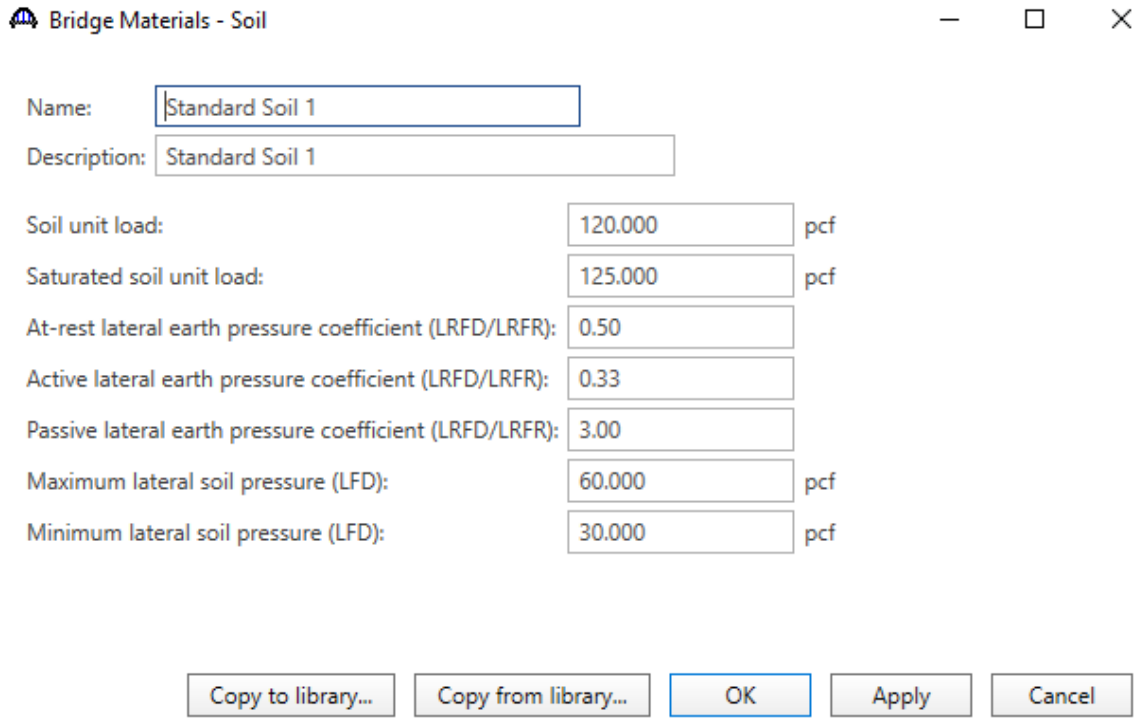


When plans are available, use the minimum concrete strength and yield strength values given in the plans. If plan values are not known, values given in Section 1 of the Bridge Rating Manual for the applicable year of construction may be followed.

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.

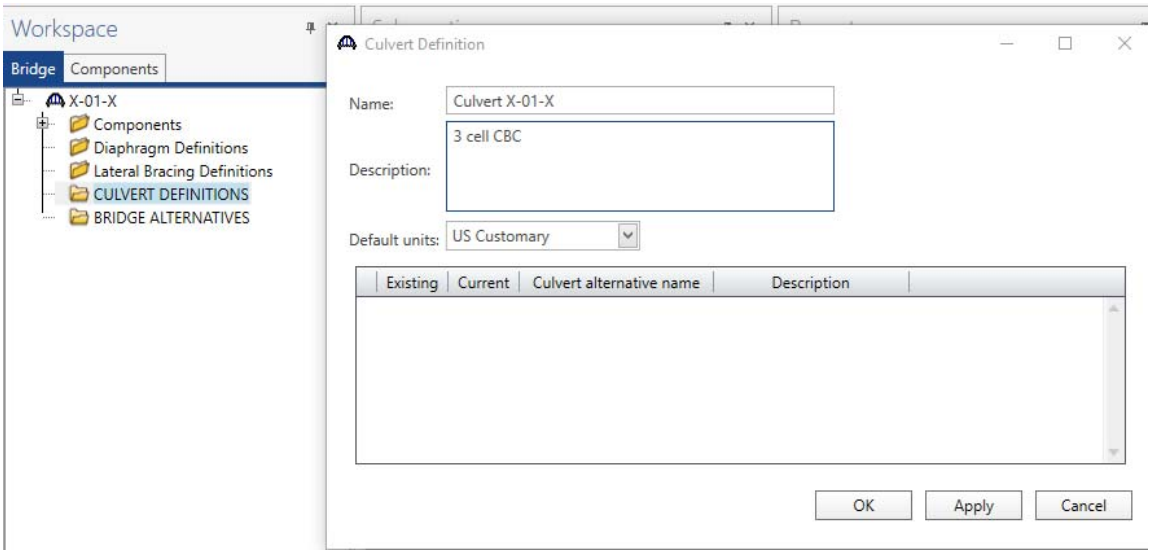


Double-click on the Soil folder to create a new soil material. Click on the Copy from Library button to copy the Standard Soil 1 material to the bridge (see Table 1-1 for Soil Material to use).

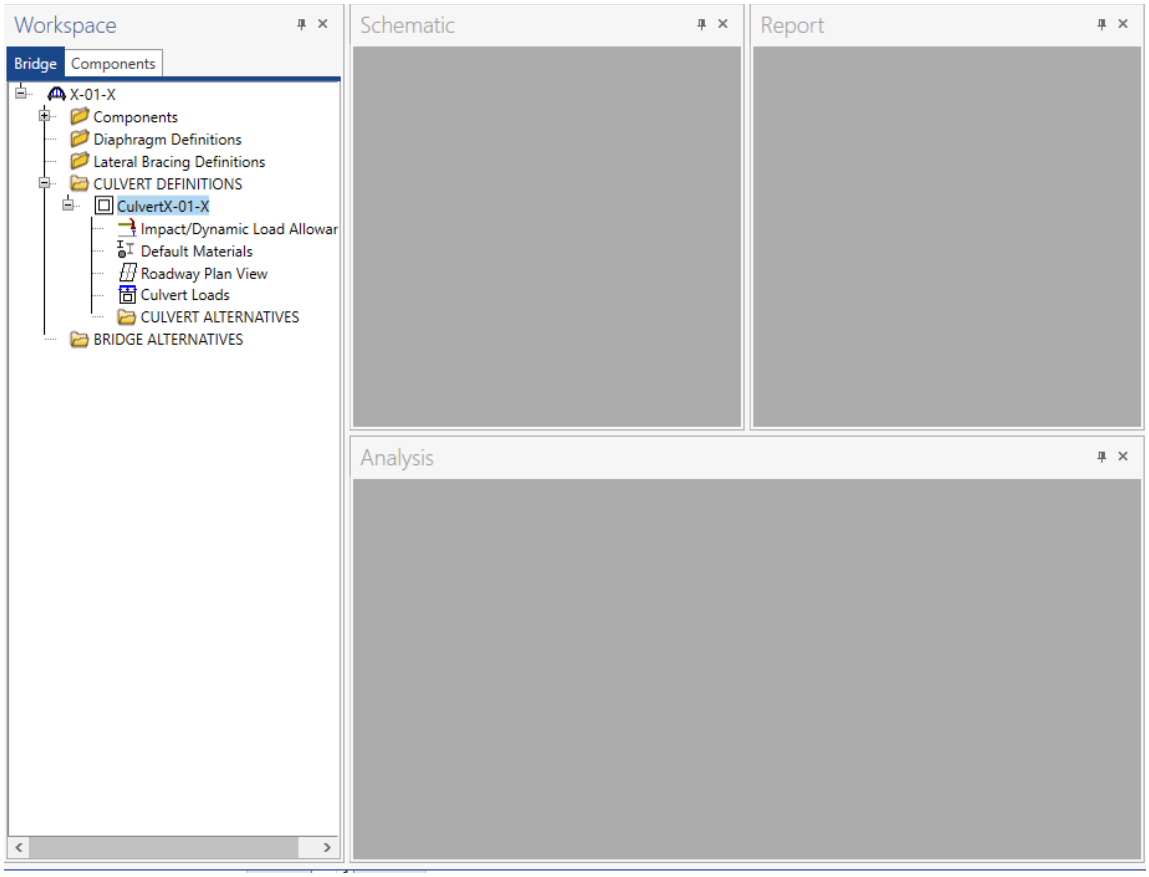


Standard Soil 1 uses for LFD and LRFD Specifications.
Standard Soil 2 uses for ASD Specification.

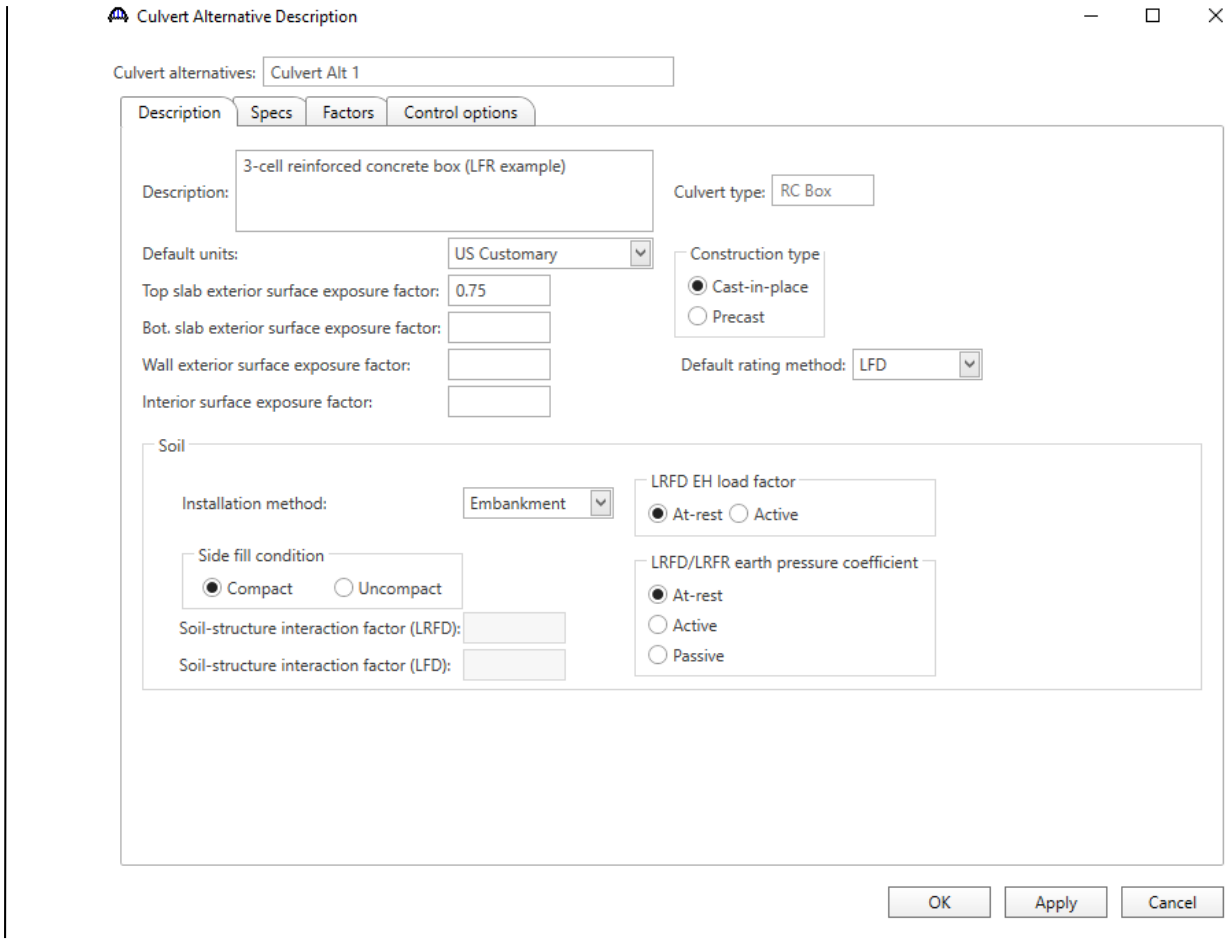
Double-click on the CULVERT DEFINITIONS folder to create a new culvert definition. Enter the Culvert Definition name as show below. The first Culvert Alternative that we create will automatically be assigned as the Existing and Current Culvert Alternative for this Culvert Definition.



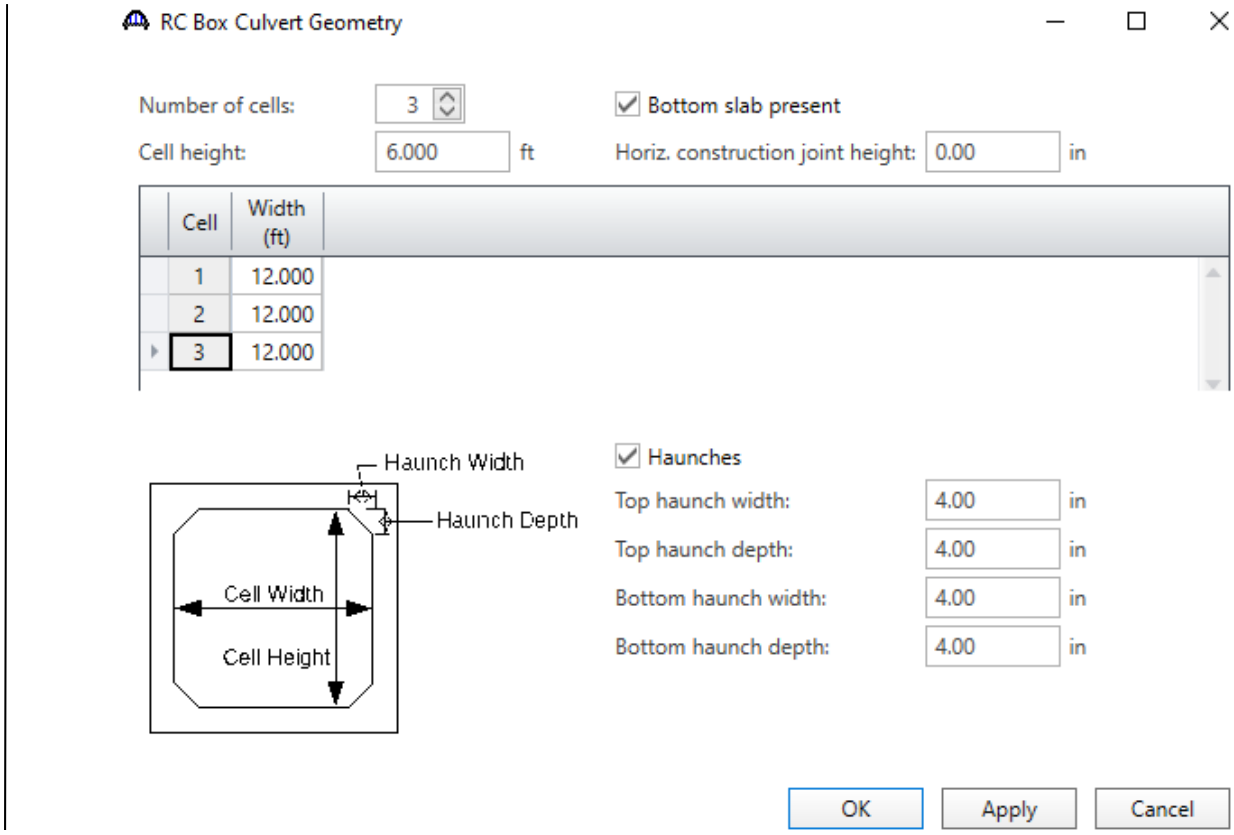
Expand the tree for Culvert Definition X-01-X.



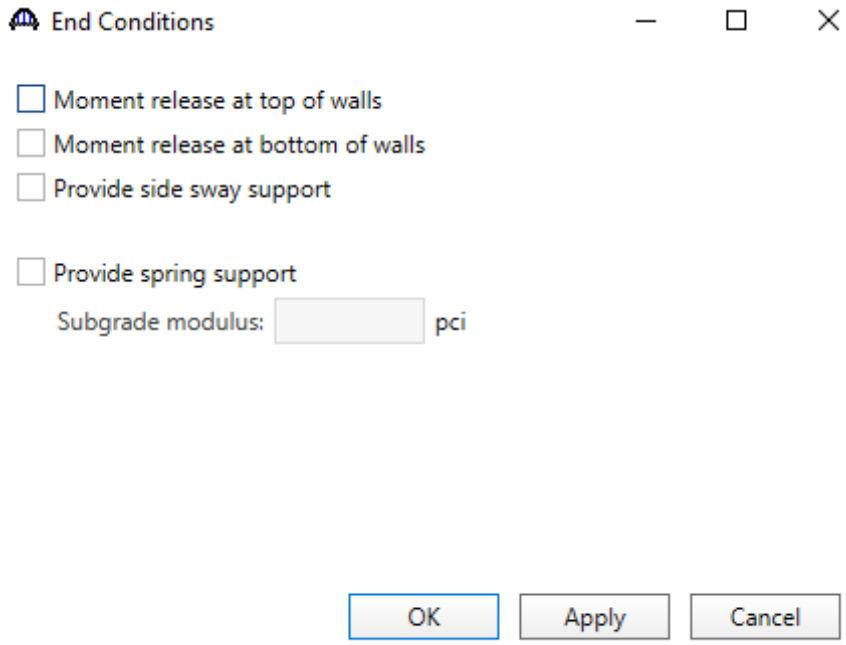
Double-click on the CULVERT ALTERNATIVES folder to create a new culvert alternative for Culvert X-01-X. Enter the data as show below.



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.

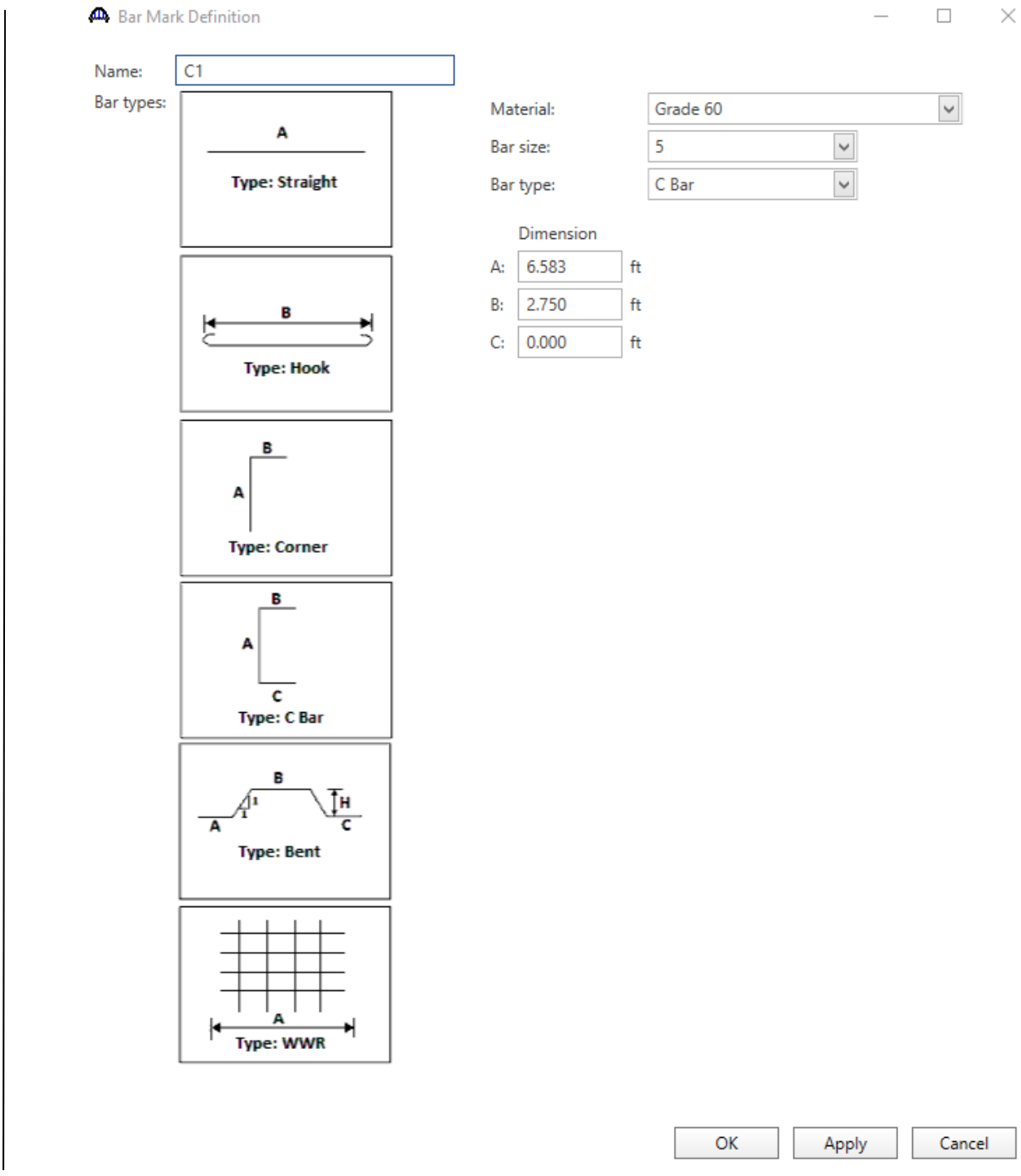


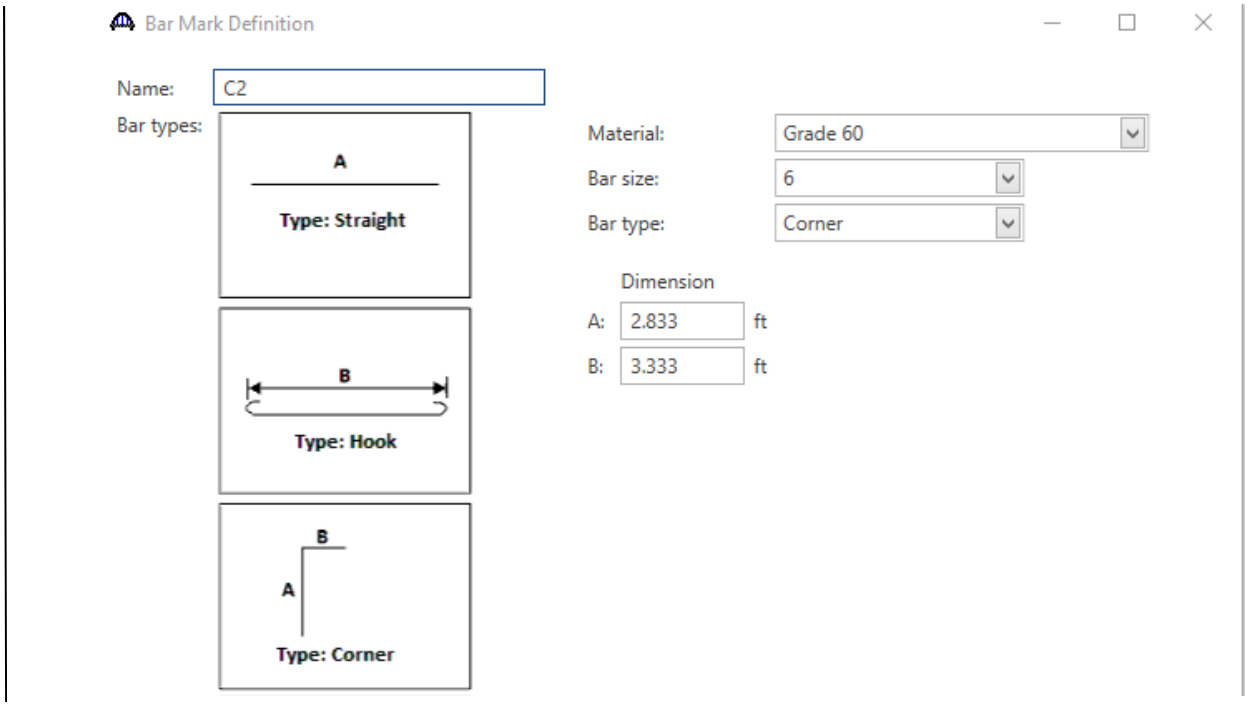
Double-click on End Conditions. Leave uncheck box if reinforcement is rigid. Spring support may be used if subgrade modulus is known. Click Ok to save the data to memory and close the window

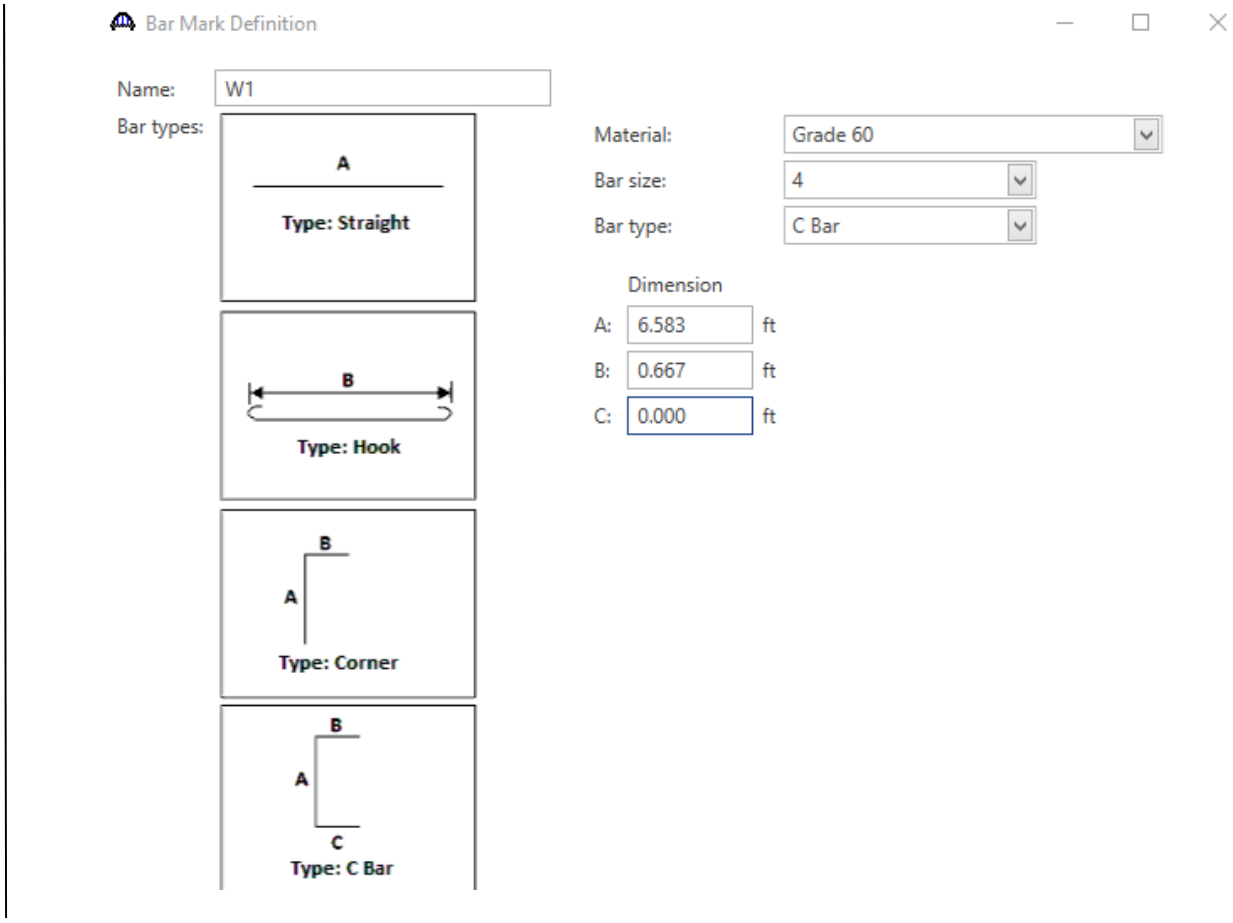


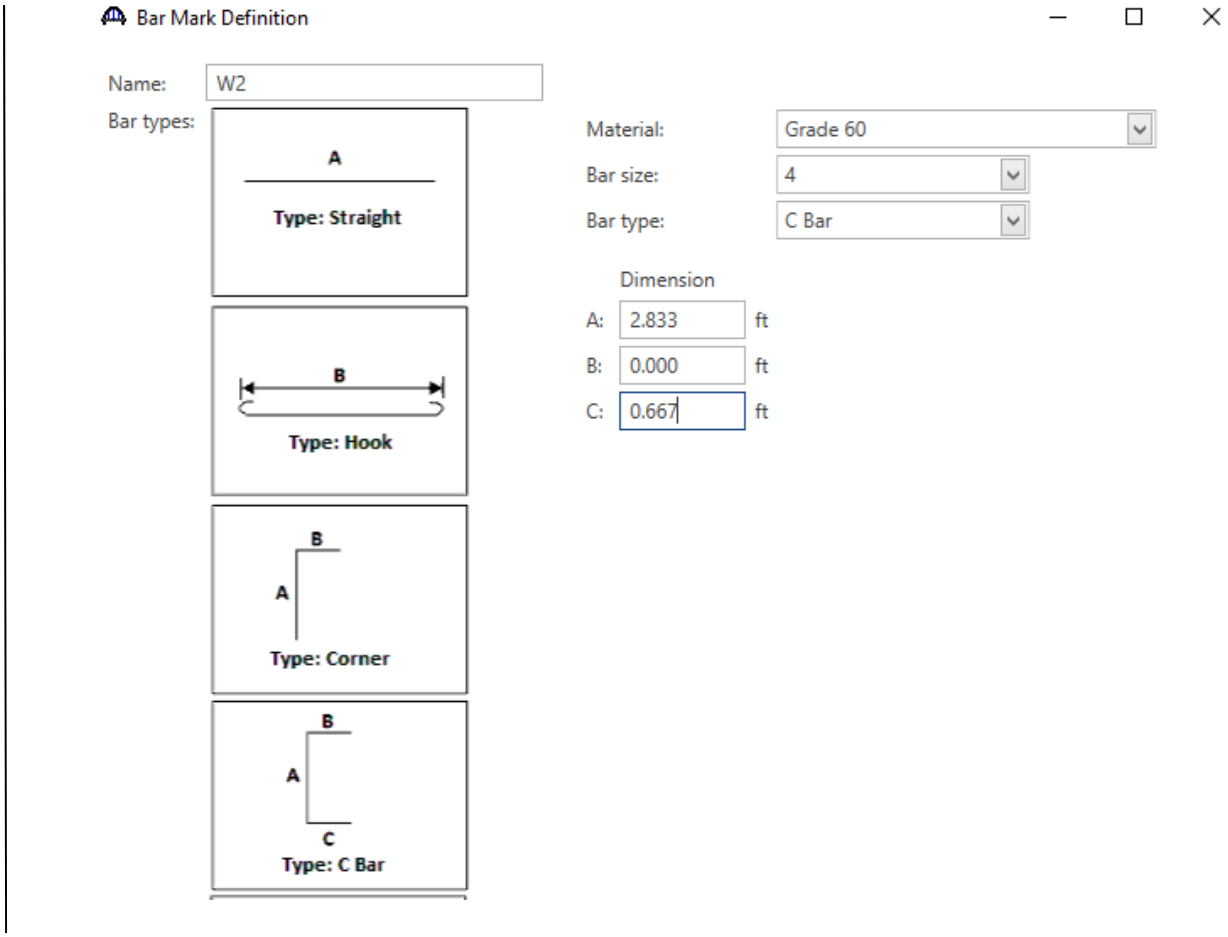
Double-click on the Bar Mark Definitions folder in the tree to create a new bar mark definition for Culvert Alt 1.

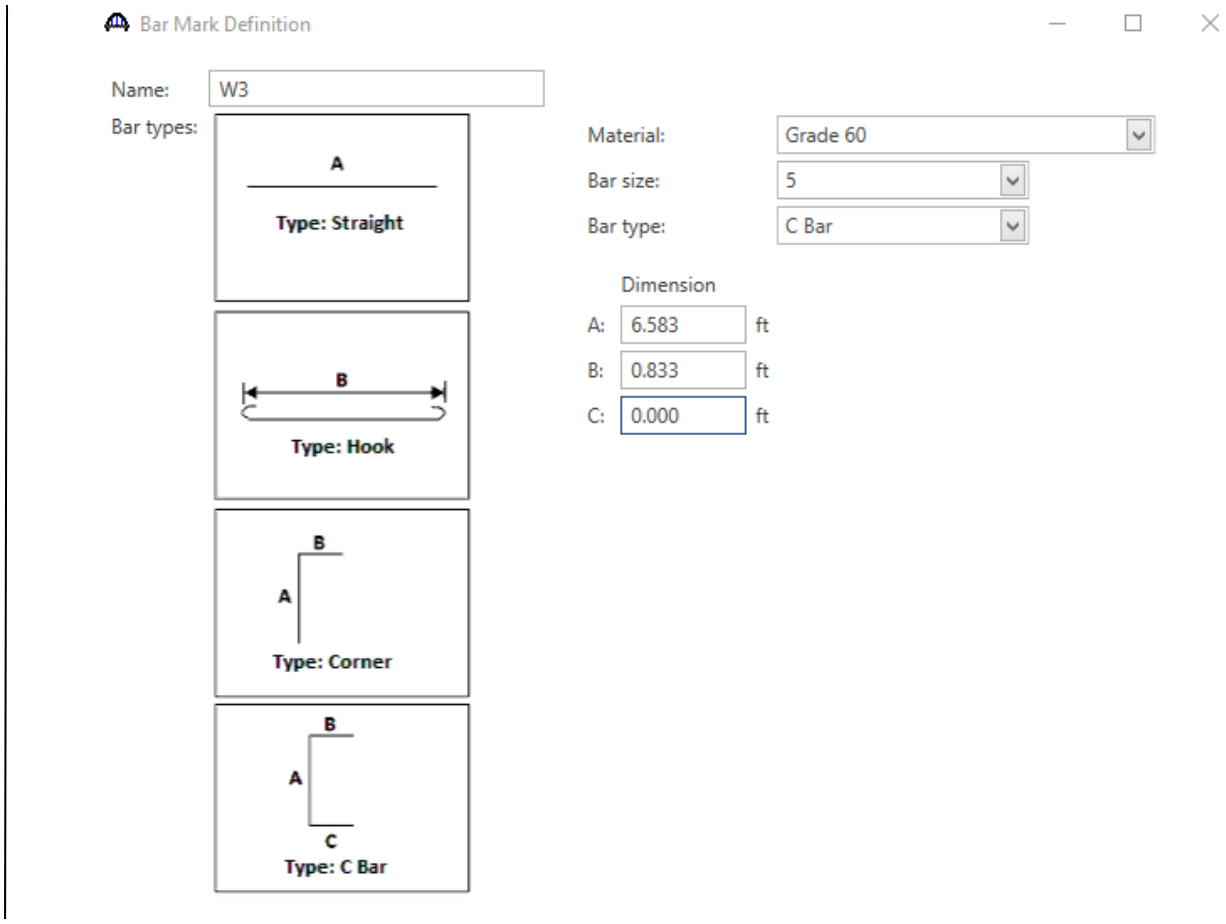
Enter the data for C1 as shown below. Click Ok to save the data to memory and close the window. Repeat the process for all bars (C2, W1, W2, W3, W4, B1, B2, T1, and T2) as shown.

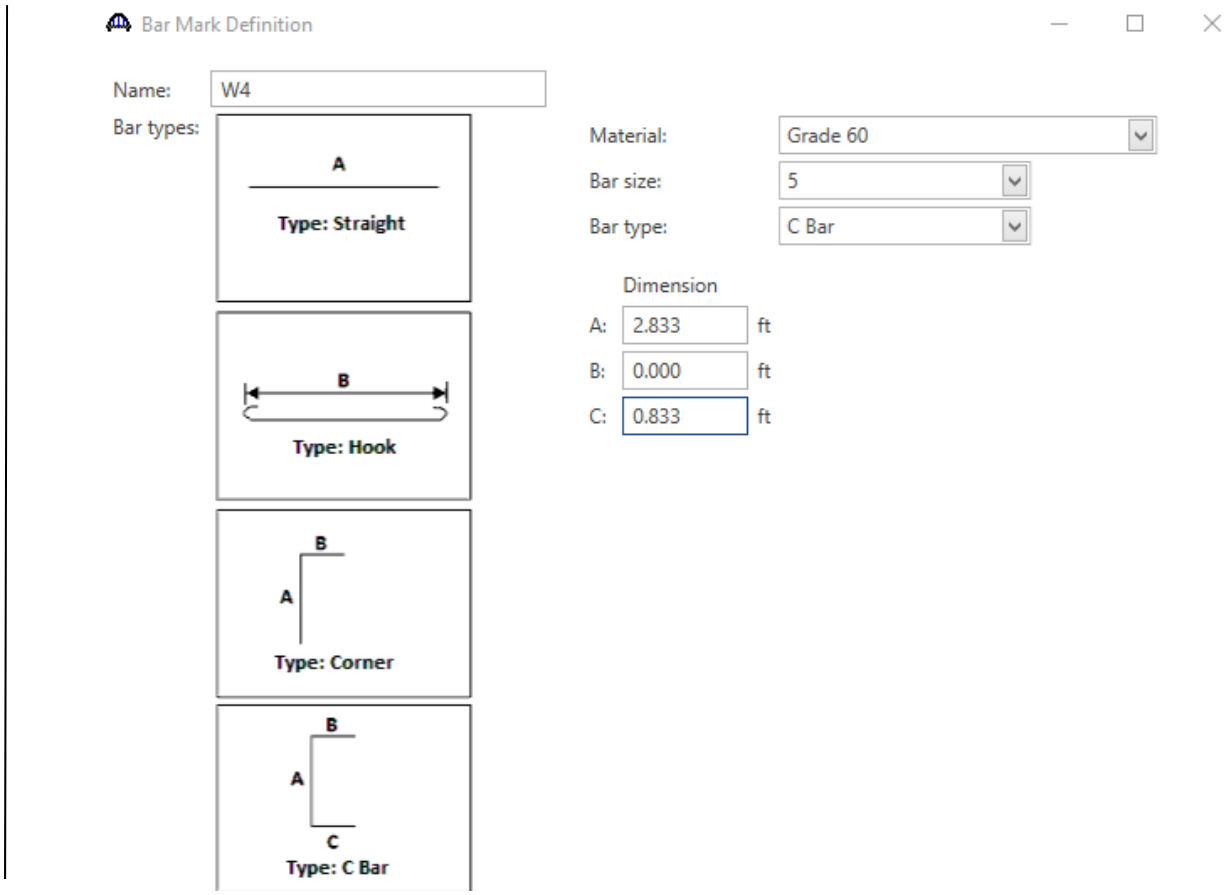


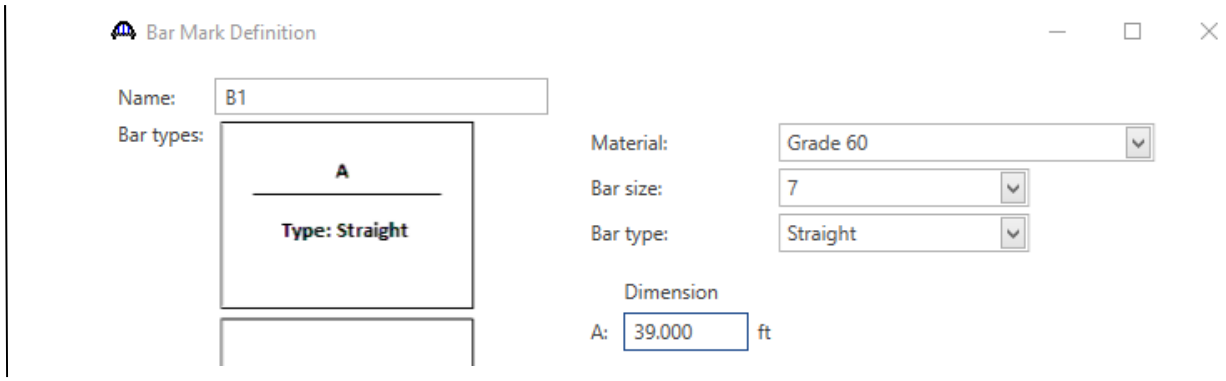

Bar Mark Definition
Name:
C2
Bar types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
Material:
Grade 60
Bar size:
6
Bar type:
Corner
Dimension
A:
2.833
ft
B:
3.333
ft

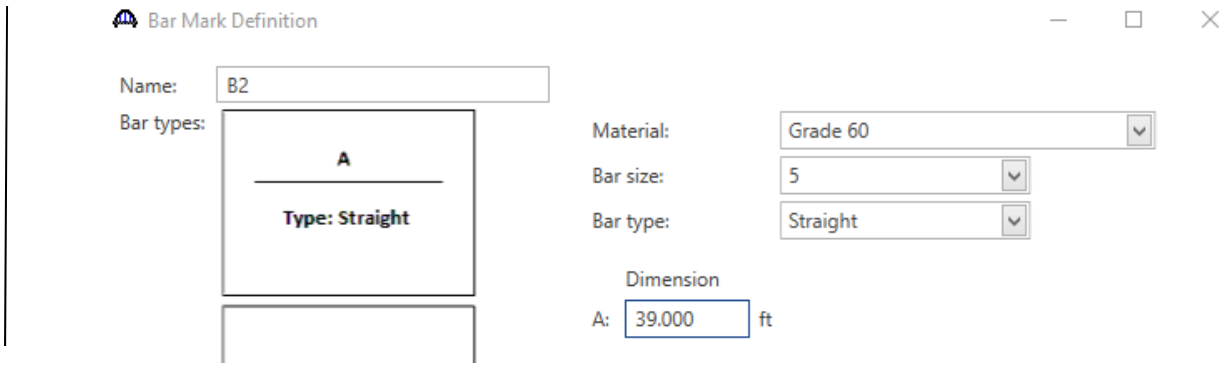

Bar Mark Definition
Name:
W1
Bar types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
B
A
C
Type: C Bar
Material:
Grade 60
Bar size:
4
Bar type:
C Bar
Dimension
A:
6.583
ft
B:
0.667
ft
C:
0.000
ft

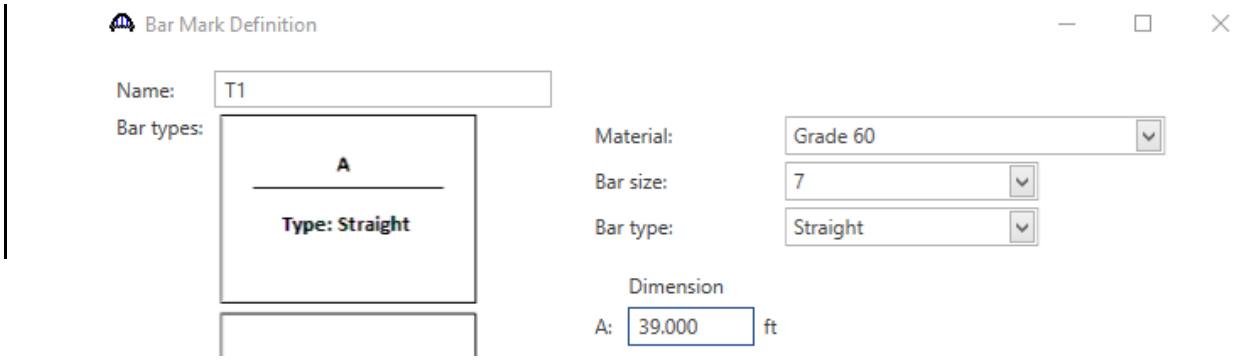

Bar Mark Definition
Name:
W2
Bar types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
B
A
C
Type: C Bar
Material:
Grade 60
Bar size:
4
Bar type:
C Bar
Dimension
A:
2.833
ft
B:
0.000
ft
C:
0.667
ft

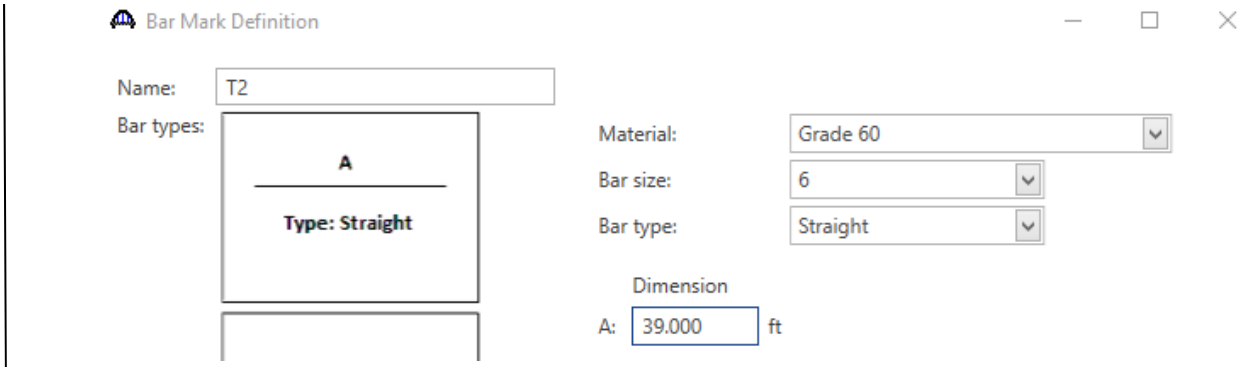

Bar Mark Definition
Name:
W3
Bar types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
B
A
C
Type: C Bar
Material:
Grade 60
Bar size:
5
Bar type:
C Bar
Dimension
A:
6.583
ft
B:
0.833
ft
C:
0.000
ft


Bar Mark Definition
Name:
W4
Bar types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
B
A
C
Type: C Bar
Material:
Grade 60
Bar size:
5
Bar type:
C Bar
Dimension
A:
2.833
ft
B:
0.000
ft
C:
0.833
ft

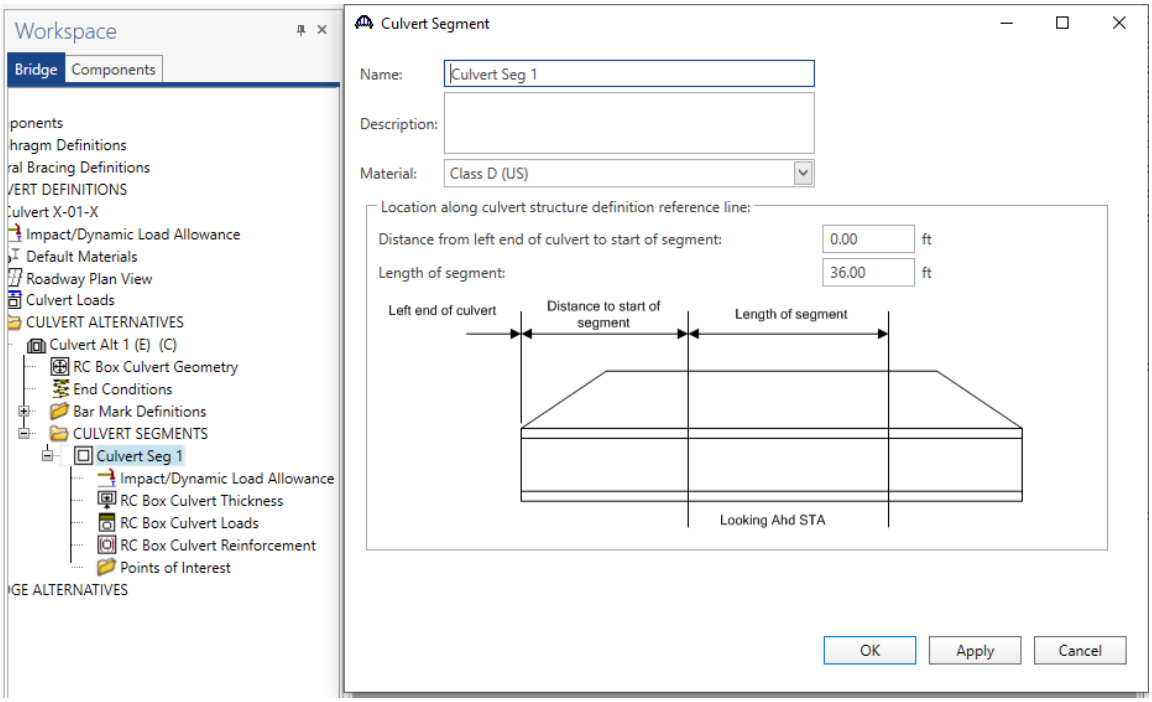

Bar Mark Definition
Name:
B1
Bar types:
A
Type: Straight
Material:
Grade 60
Bar size:
7
Bar type:
Straight
Dimension
A:
39.000
ft


Bar Mark Definition
Name:
B2
Bar types:
A
Type: Straight
Material:
Grade 60
Bar size:
5
Bar type:
Straight
Dimension
A:
39.000
ft

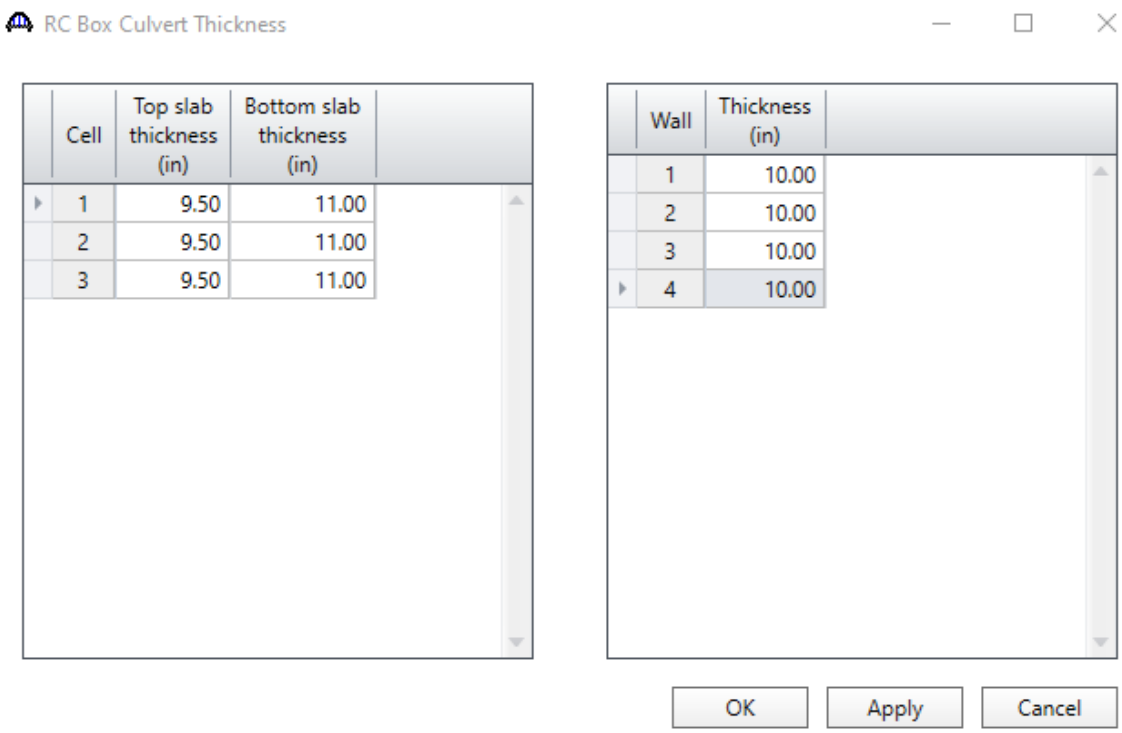

Bar Mark Definition
Name:
T1
Bar types:
A
Type: Straight
Material:
Grade 60
Bar size:
7
Bar type:
Straight
Dimension
A:
39.000
ft


Bar Mark Definition
Name:
T2
Bar types:
A
Type: Straight
Material:
Grade 60
Bar size:
6
Bar type:
Straight
Dimension
A:
39.000
ft

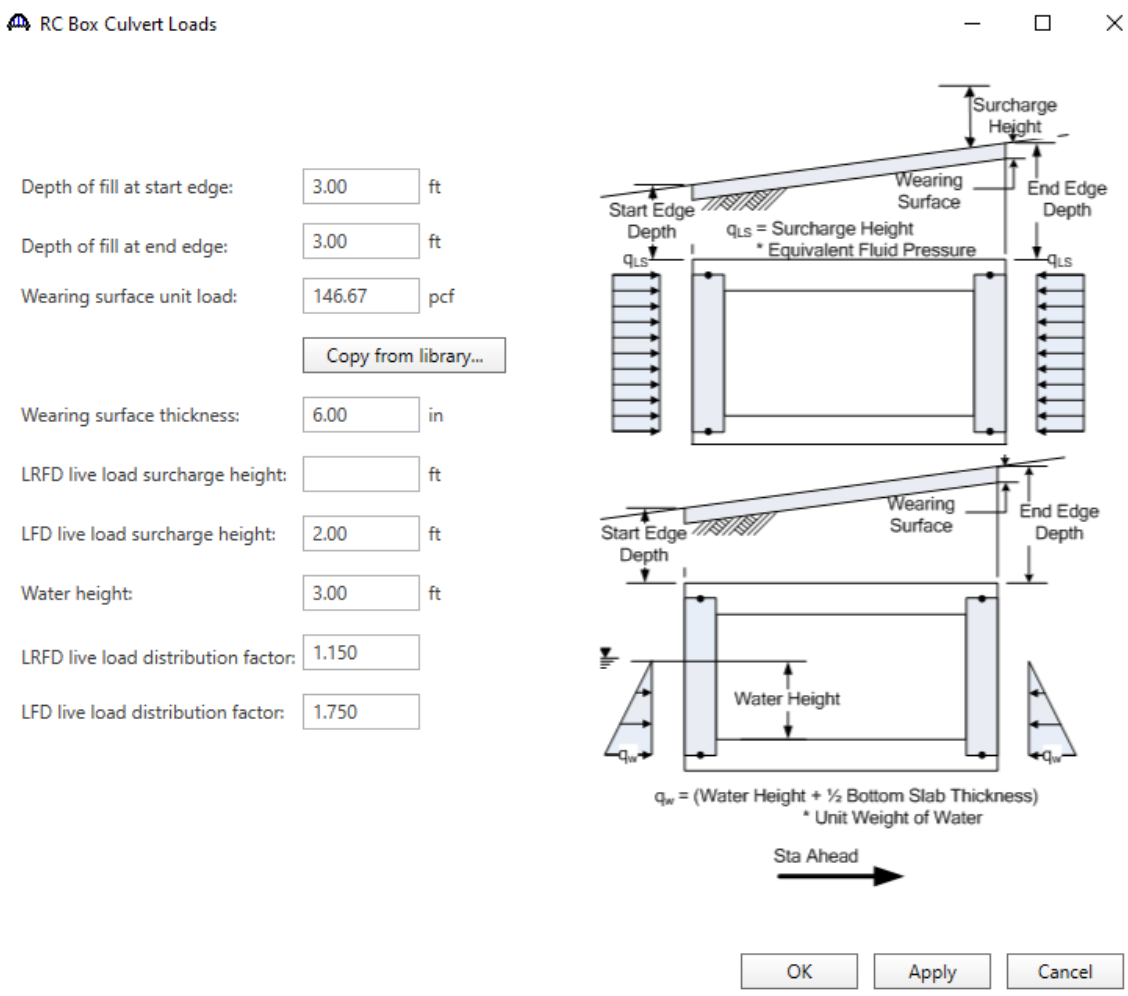
Double-click on the CULVERT SEGMENTS folder to create a new culvert segment for Culvert Alt 1. A culvert alternative may have one or more culvert segments. Enter the data as shown below.



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.

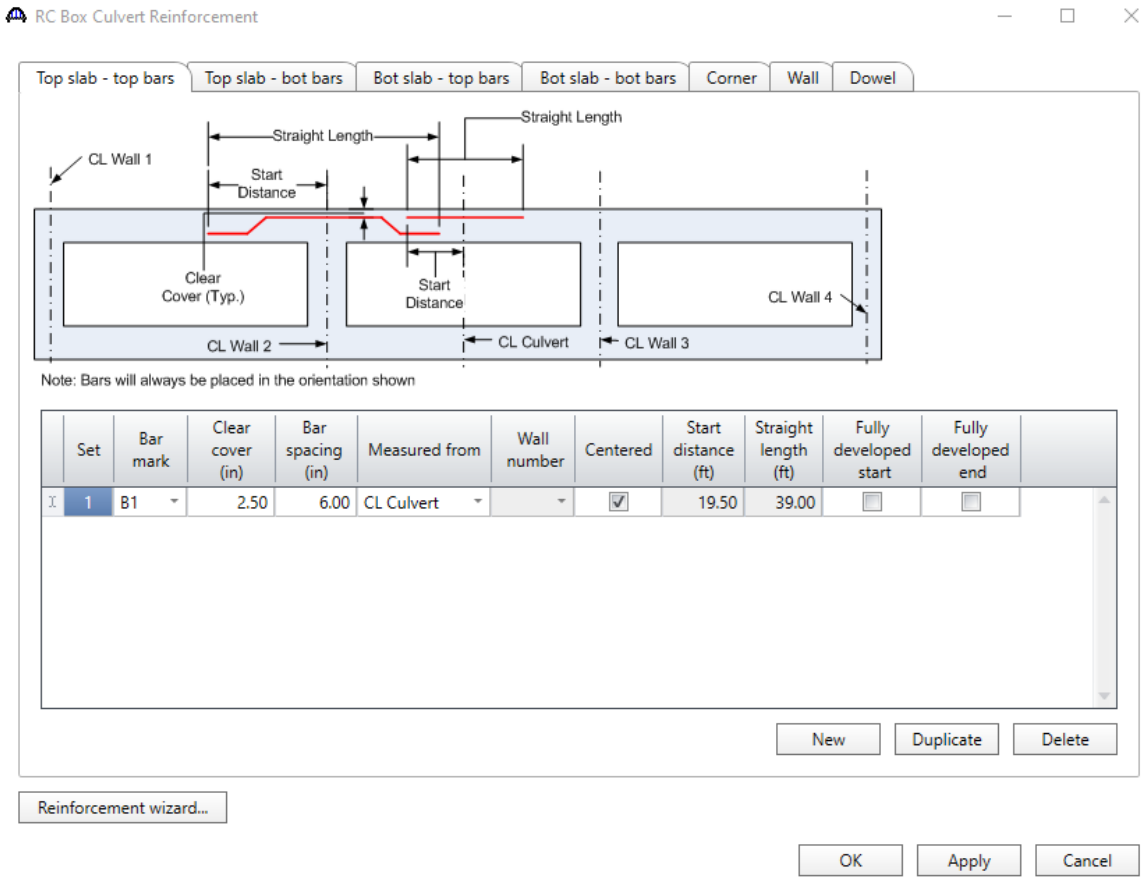


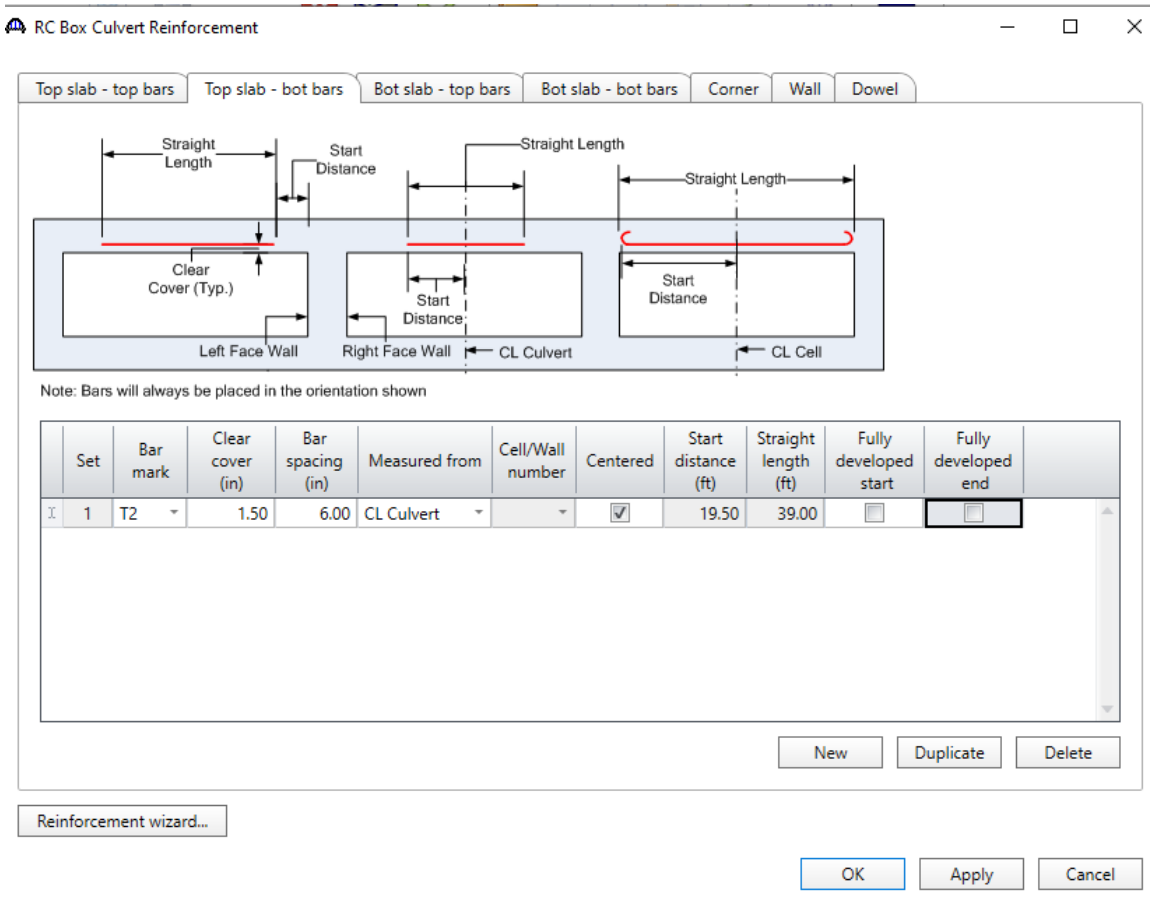
Double-click on RC Box Culvert Loads in the tree. Enter the culvert loads for Culvert Seg 1 as shown below. The wearing surface thickness includes the equivalent for the rail dead load. Click OK to save the data to memory and close the window.

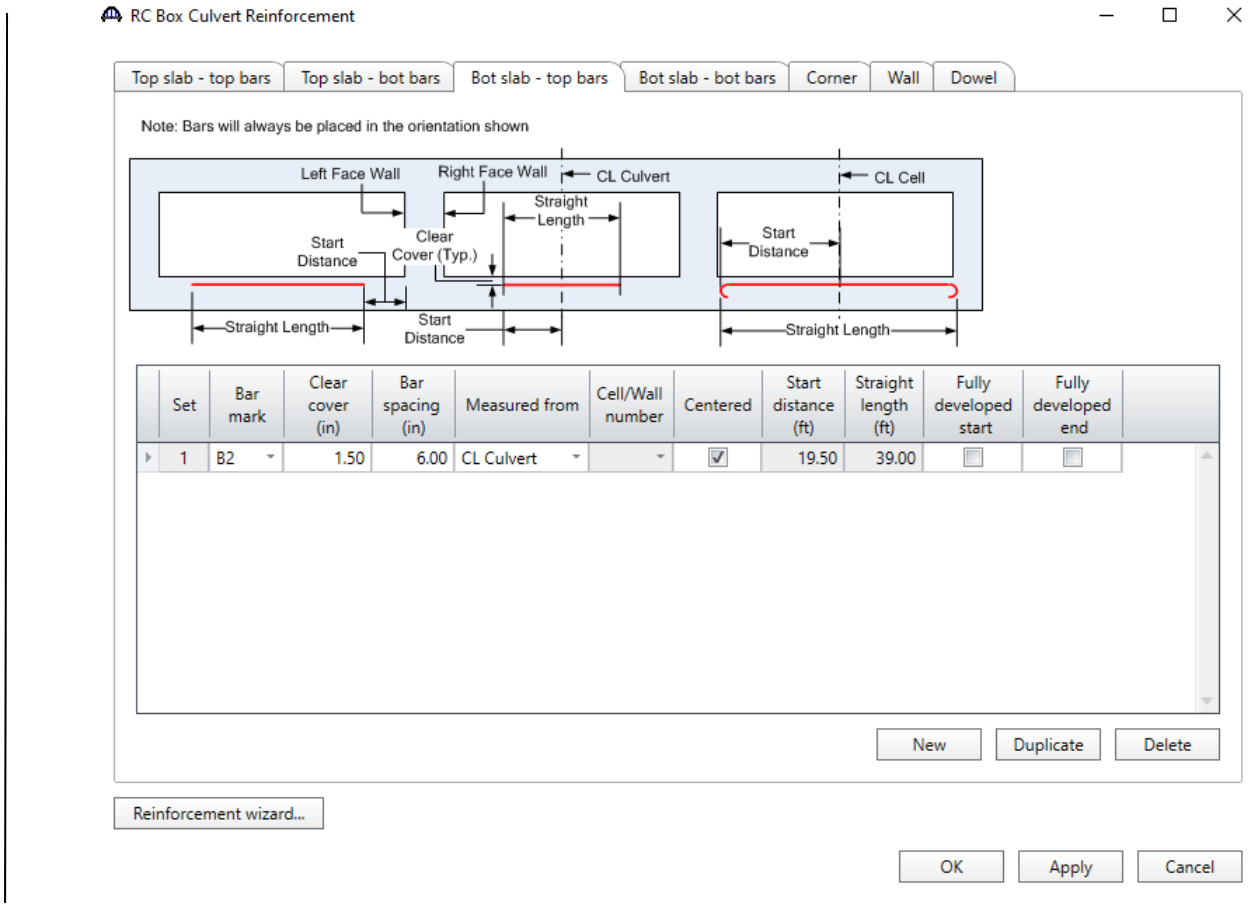


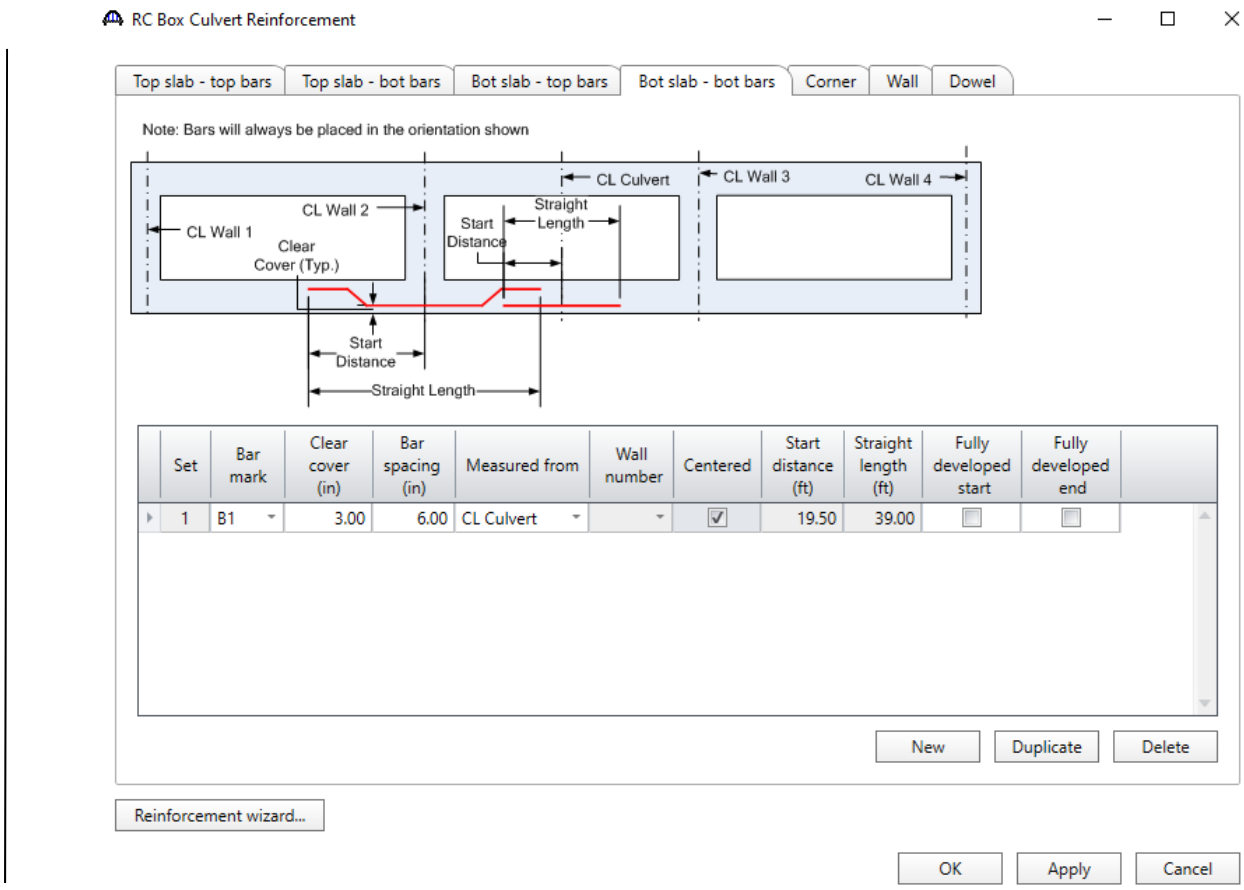
Use water height half the rise of the culvert.

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.



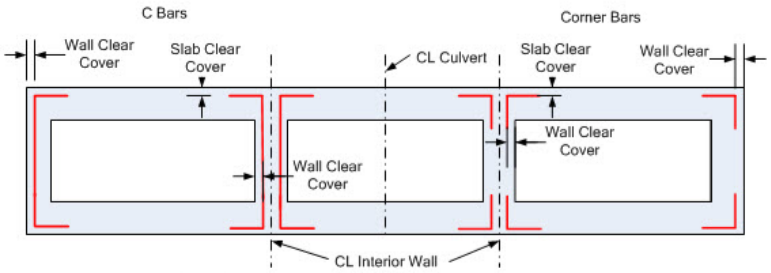

RC Box Culvert Reinforcement
Top slab - top bars
Top slab - bot bars
Bot slab - top bars
Bot slab - bot bars
Corner
Wall
Dowel
Straight Length
Start Distance
Straight Length
Straight Length
Clear Cover (Typ.)
Start Distance
Start Distance
Left Face Wall
Right Face Wall
CL Culvert
CL Cell
Note: Bars will 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
T2
1.50
6.00
CL Culvert
19.50
39.00
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
B2
1.50
6.00
CL Culvert
19.50
39.00
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.)
Start Distance
Straight Length
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
B1
3.00
6.00
CL Culvert
19.50
39.00
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

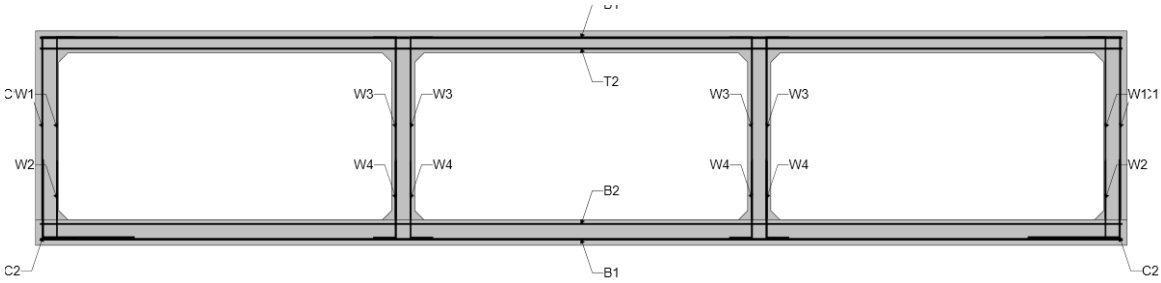
	Set	Bar mark	Wall clear cover (in)	Slab clear cover (in)	Bar spacing (in)	Location	Wall Number	Fully developed vert	Fully developed horz
	1	C2	2.00	3.00	6.00	Bottom Right	1	☐	☐
	2	C2	2.00	3.00	6.00	Bottom Left	4	☐	☐
	3	C1	2.00	2.50	6.00	Right	1	☐	☐
	4	C1	2.00	2.50	6.00	Left	4	☐	☐
	5	W1	8.50	2.50	6.00	Right	1	☐	☐
	6	W1	8.50	2.50	6.00	Left	4	☐	☐
	7	W2	8.50	55.50	6.00	Right	1	☐	☐
	8	W2	8.50	55.50	6.00	Left	4	☐	☐
	9	W3	1.50	2.50	6.00	Left	2	☐	☐
	10	W3	1.50	2.50	6.00	Left	3	☐	☐
	11	W3	1.50	2.50	6.00	Right	2	☐	☐
	12	W3	1.50	2.50	6.00	Right	3	☐	☐
	13	W4	1.50	55.50	6.00	Left	2	☐	☐
	14	W4	1.50	55.50	6.00	Right	2	☐	☐
	15	W4	1.50	55.50	6.00	Left	3	☐	☐
▸	16	W4	1.50	55.50	6.00	Right	3	☐	☐

New | Duplicate | Delete

Reinforcement wizard...

OK | Apply | Cancel

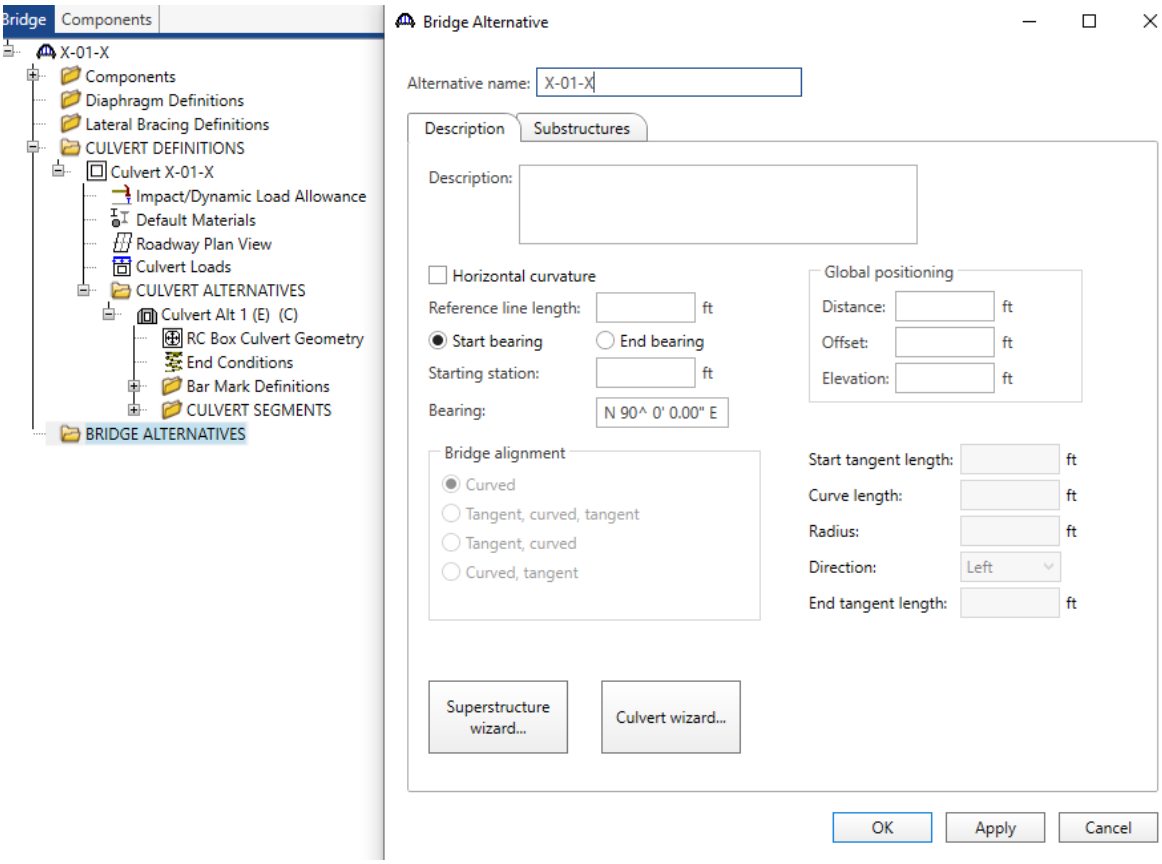
Select Bridge | Schematic to review the reinforcement data.



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

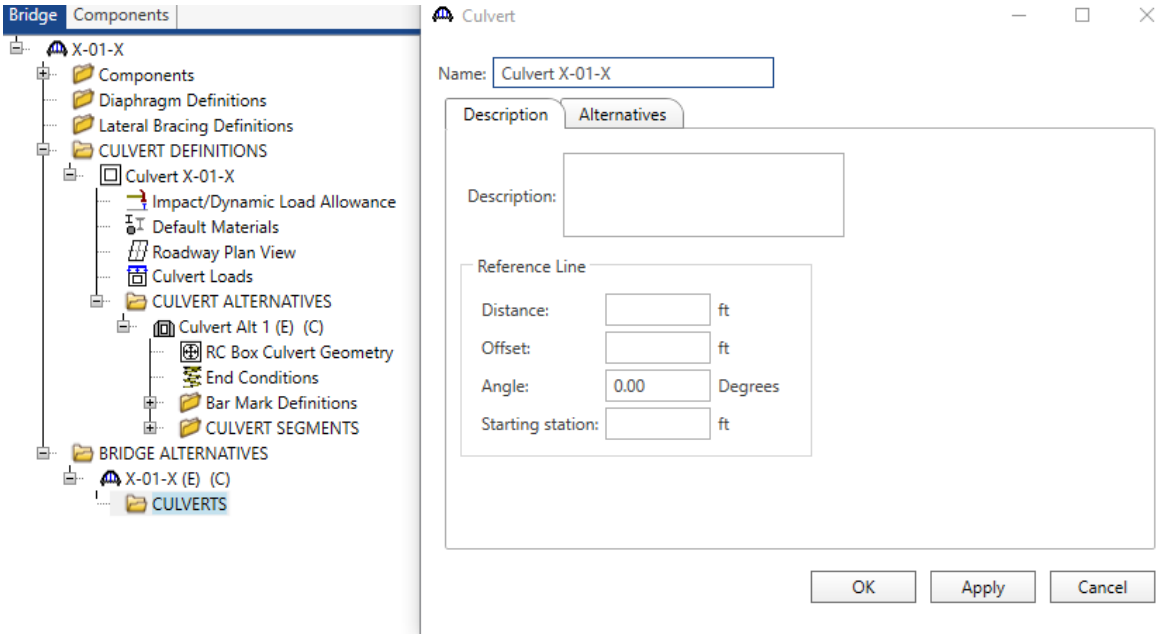
Select File | Save to save the file in BrR.

Double-click on Bridge Alternatives to create a Bridge Alternative name. Enter the Alternative name as show below.



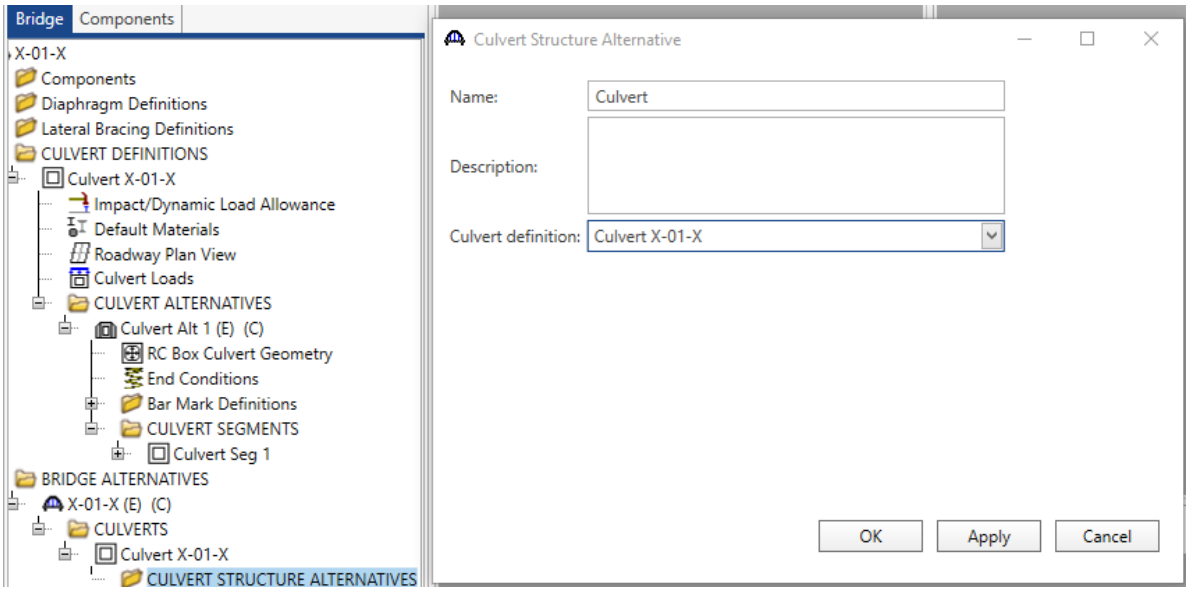
Click Ok to save the data to memory and close the window.

Double-click on Culverts to create a culvert name. Enter the Culvert name as show below.



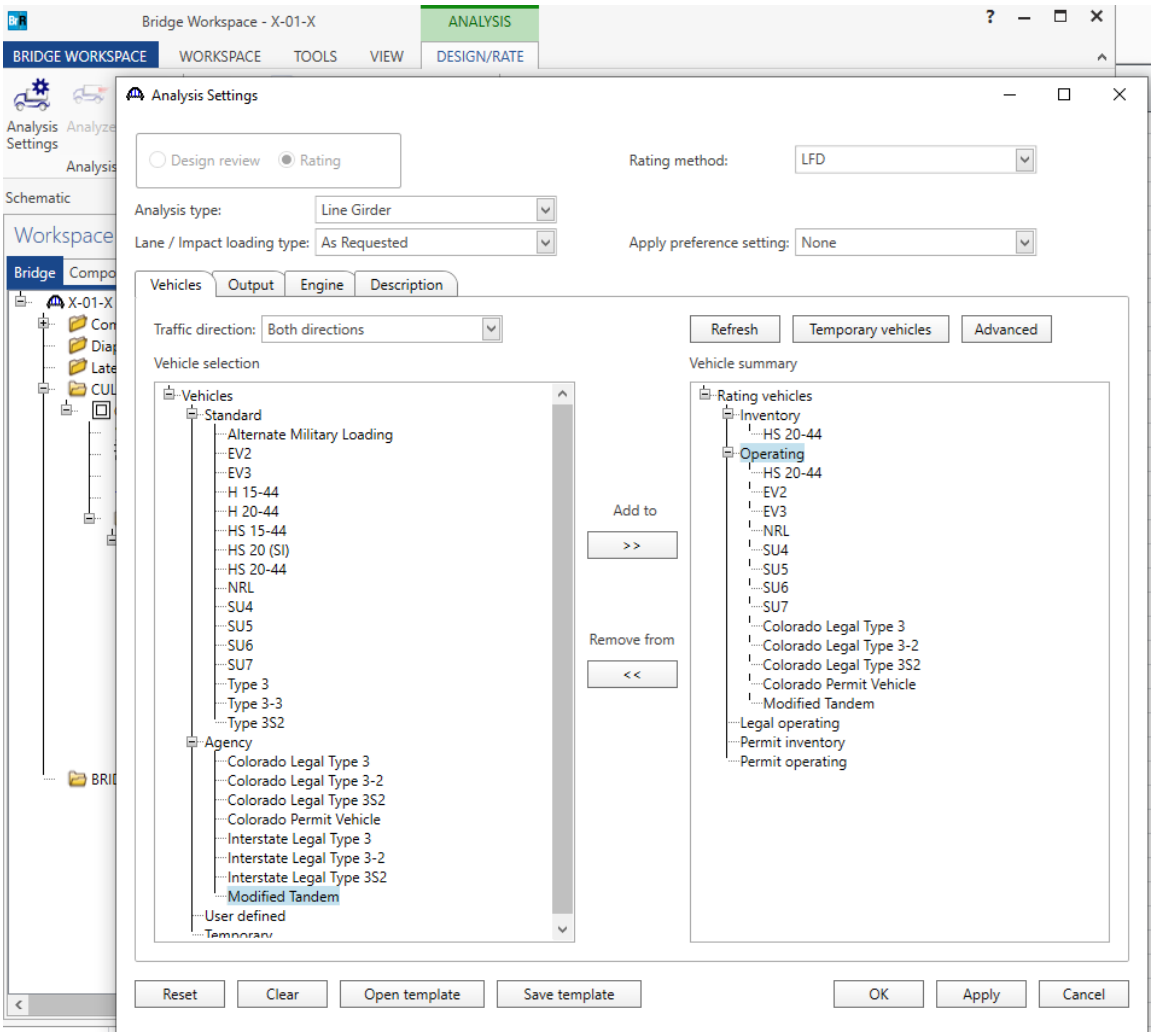
Click Ok to save the data to memory and close the window.

Double-click on Culvert Structure Alternatives to create a culvert name. Enter the Culvert Structure Alternative name as show below.



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

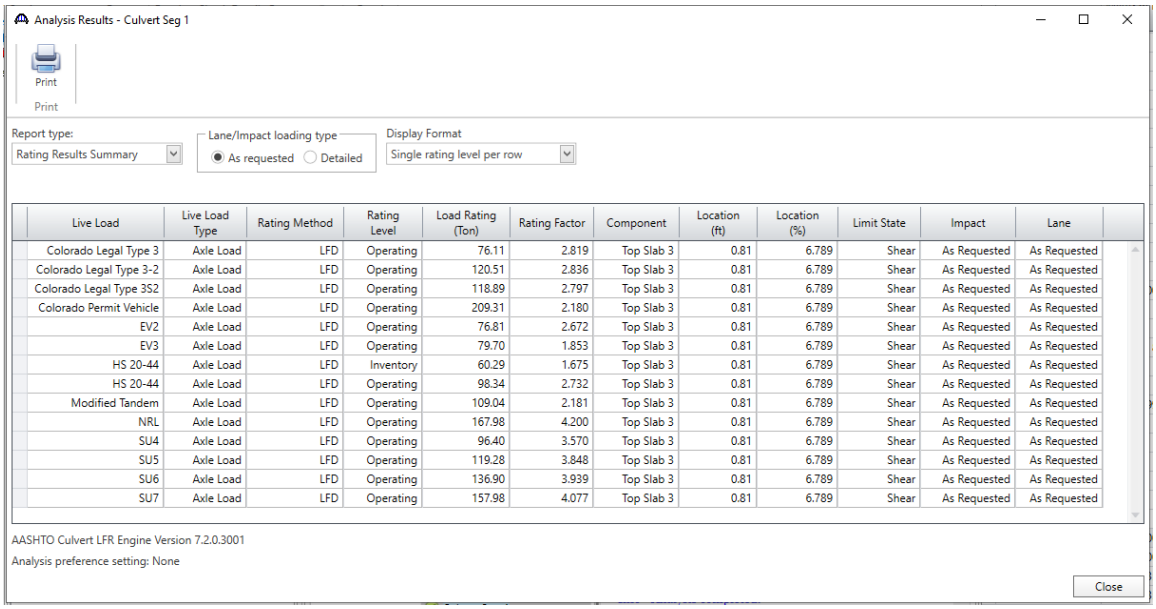
To perform LFD Design Load Rating, open the Analysis setting window by selecting Bridge | Analysis Settings. Select LFD as the Rating Method and specify the vehicles. Under Vehicles → Advanced.. select Single Lane Loaded for Colorado Permit Vehicle and Modified Tandem.



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
Colorado Legal Type 3	Axle Load	LFD	Operating	76.11	2.819	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Legal Type 3-2	Axle Load	LFD	Operating	120.51	2.836	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Legal Type 3S2	Axle Load	LFD	Operating	118.89	2.797	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Permit Vehicle	Axle Load	LFD	Operating	209.31	2.180	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
EV2	Axle Load	LFD	Operating	76.81	2.672	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
EV3	Axle Load	LFD	Operating	79.70	1.853	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
HS 20-44	Axle Load	LFD	Inventory	60.29	1.675	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	98.34	2.732	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Modified Tandem	Axle Load	LFD	Operating	109.04	2.181	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
NRL	Axle Load	LFD	Operating	167.98	4.200	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU4	Axle Load	LFD	Operating	96.40	3.570	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU5	Axle Load	LFD	Operating	119.28	3.848	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU6	Axle Load	LFD	Operating	136.90	3.939	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU7	Axle Load	LFD	Operating	157.98	4.077	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested

Fill out the Rating Summary Sheet using policies and guidelines in the Bridge Rating Manual, Section 1. The results of the LFD rating analysis are as follows.

COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

Rated using:
Asphalt thickness: 6 in.
☑ Colorado legal loads ☐ Interstate legal loads
☑ Multi-lane for Legal & Permit Vehicles ☐ Single lane for Legal & Permit Vehicles

Structure #	X-01-X
State Highway #	US X
Batch I.D.	XXXX
Structure Type	CBC
Parallel Structure #	NA

Structural Member	3-CELL CBC				
	Tons				
Inventory	60.2				
Operating	98.3				

Type 3 truck	76.1				
Type 3S2 truck	118.8				
Type 3-2 truck	120.5				
Type SU4 truck (27T)	96.4				
Type SU5 truck (31T)	119.2				
Type SU6 truck (35T)	136.9				
Type SU7 truck (39T)	157.9				
NRL (40T)	167.9				
EV2 (28.75T)	76.8				
EV3 (43T)	79.7				
Permit Truck (96T)	209.3				
Modified Tandem (50T)	109.0				

Comments:

Total structure length (face to face of end walls) = 36'-0"
Fill height 3'-0" ; Asphalt 6".
NBI Item 62 condition state level = 8 ; Plans available = Yes
Load induced damage present = No ; Pending essential repairs = No
Color Code = White
Rated with BrR v7.2.0.3001 AASHTO Culvert Engine

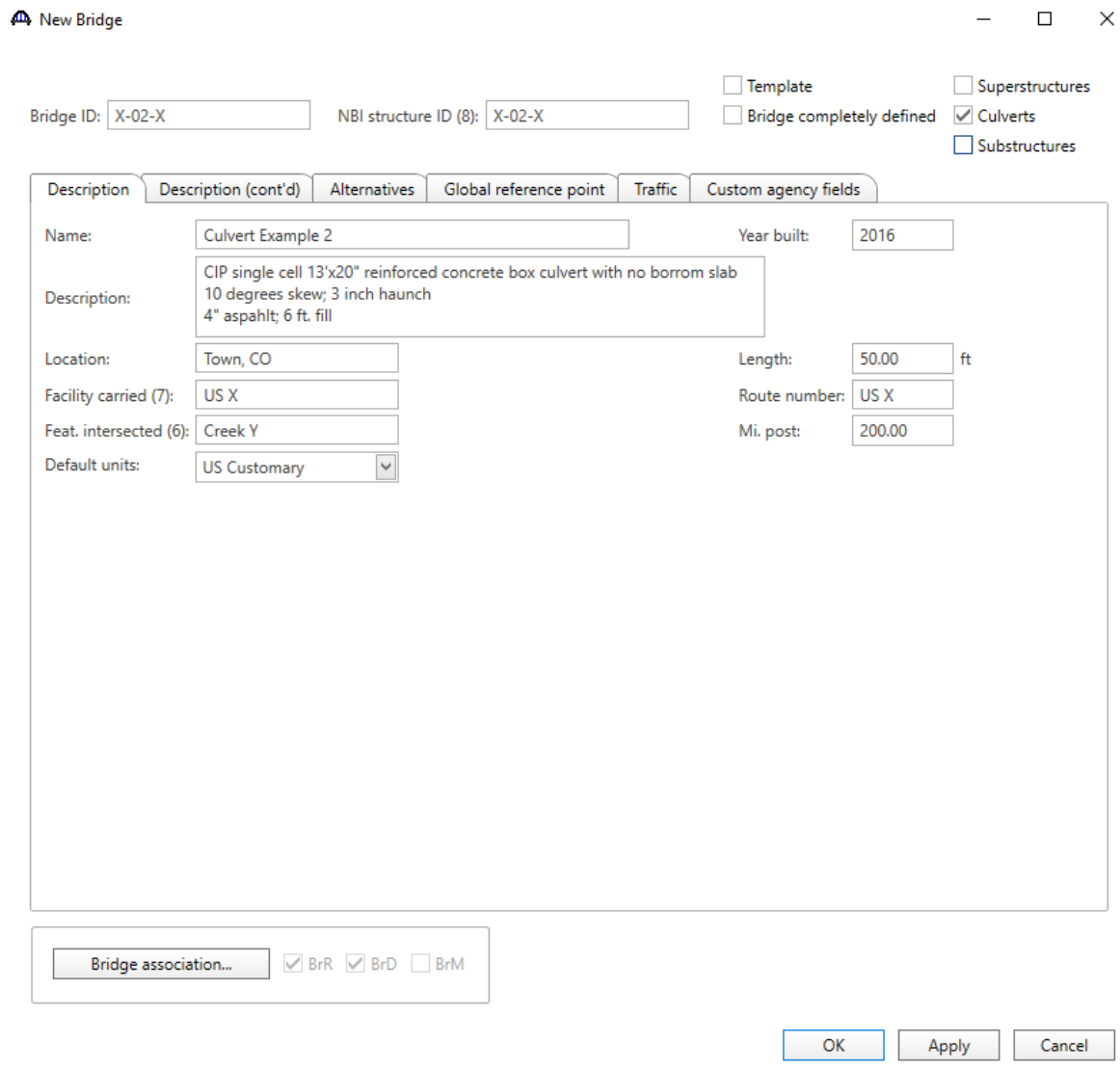
PE Seal

Rated by: (Print name and sign)	Date:	Checked by: (Print name and sign)	Date:

CDOT Staff Bridge - LFR 02/2019

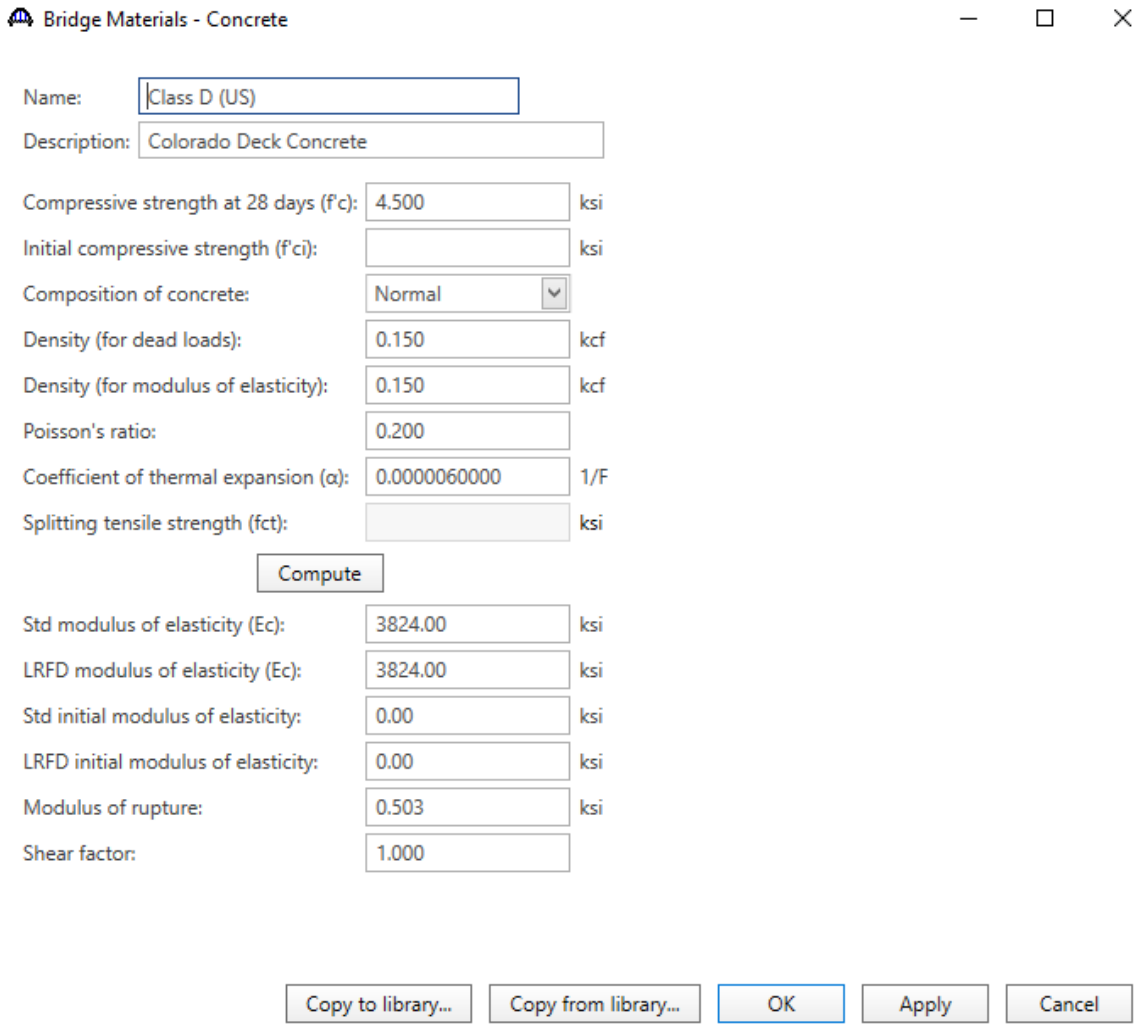
14.4.2 **AASHTOWare** BrR Program, Example 2 (LRFR) – Structure No. X-02-X

From the Bridge Explorer, select File│ New│ New Bridge to create a new bridge and then enter the following description information.



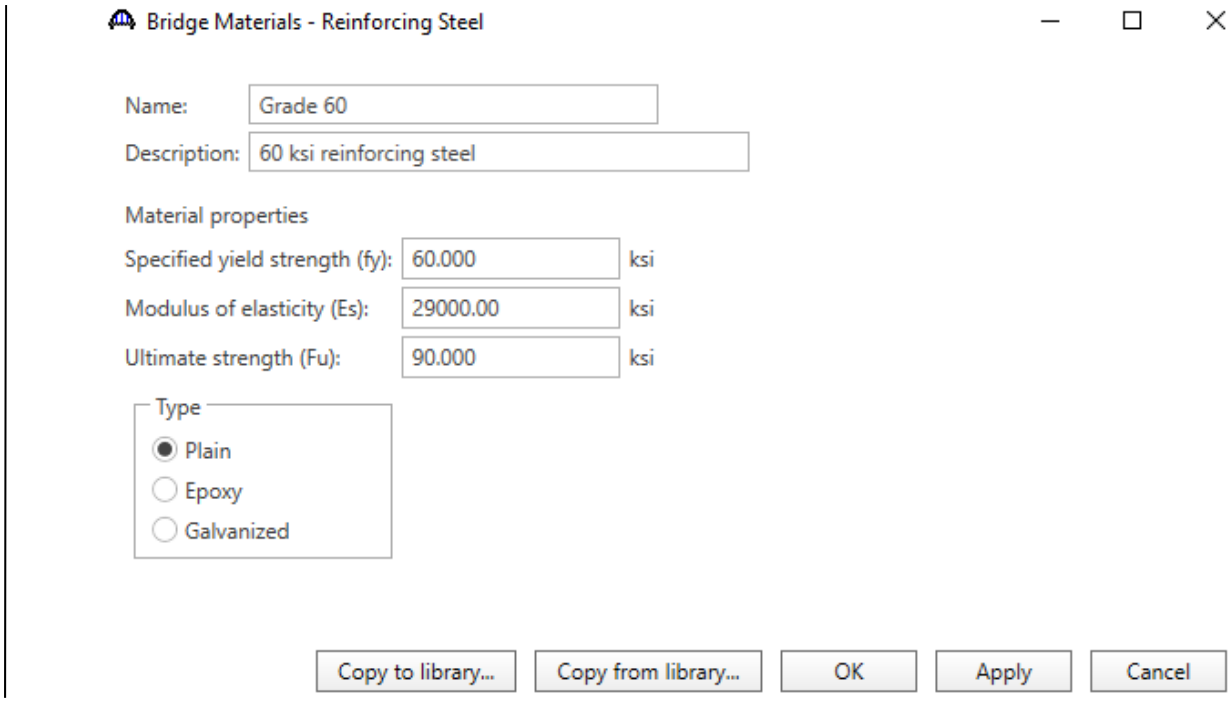
Close the window by clicking OK. This saves the data to memory and closes the window.

To enter the materials for the culvert, expand the tree for Materials. Double-click on the Concrete folder to create a new concrete material. Enter the following values.

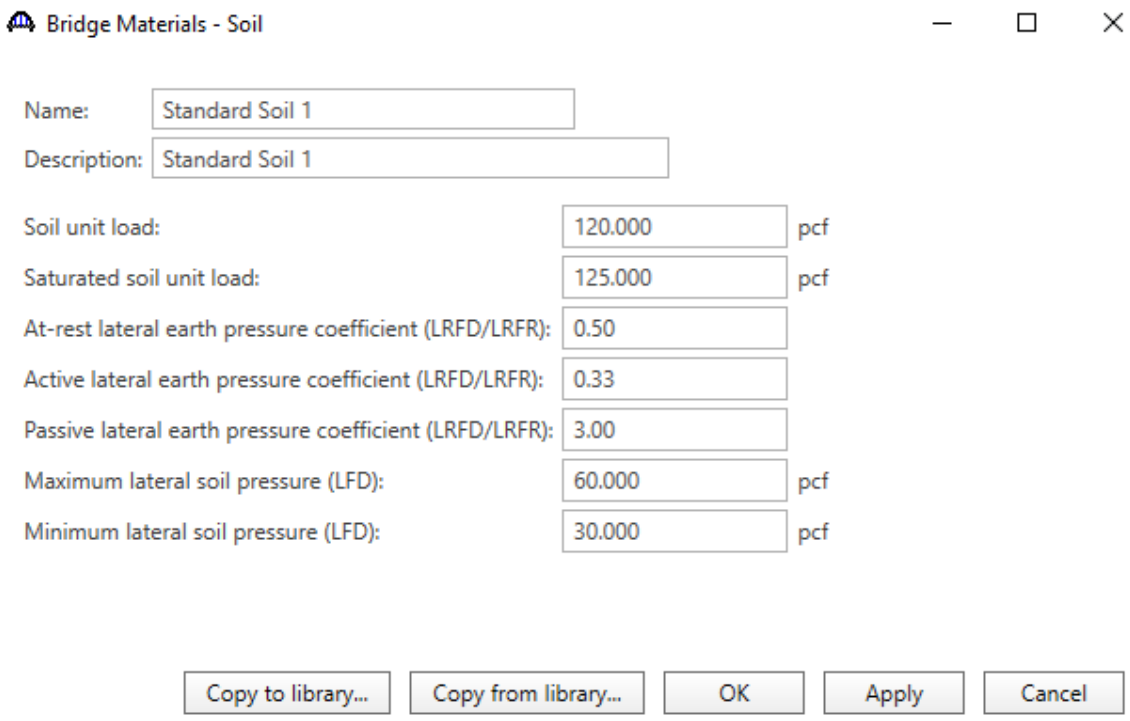


When plans are available, use the minimum concrete strength and yield strength values given in the plans. If plan values are not known, values given in Section 1 of the Bridge Rating Manual for the applicable year of construction may be followed.

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.

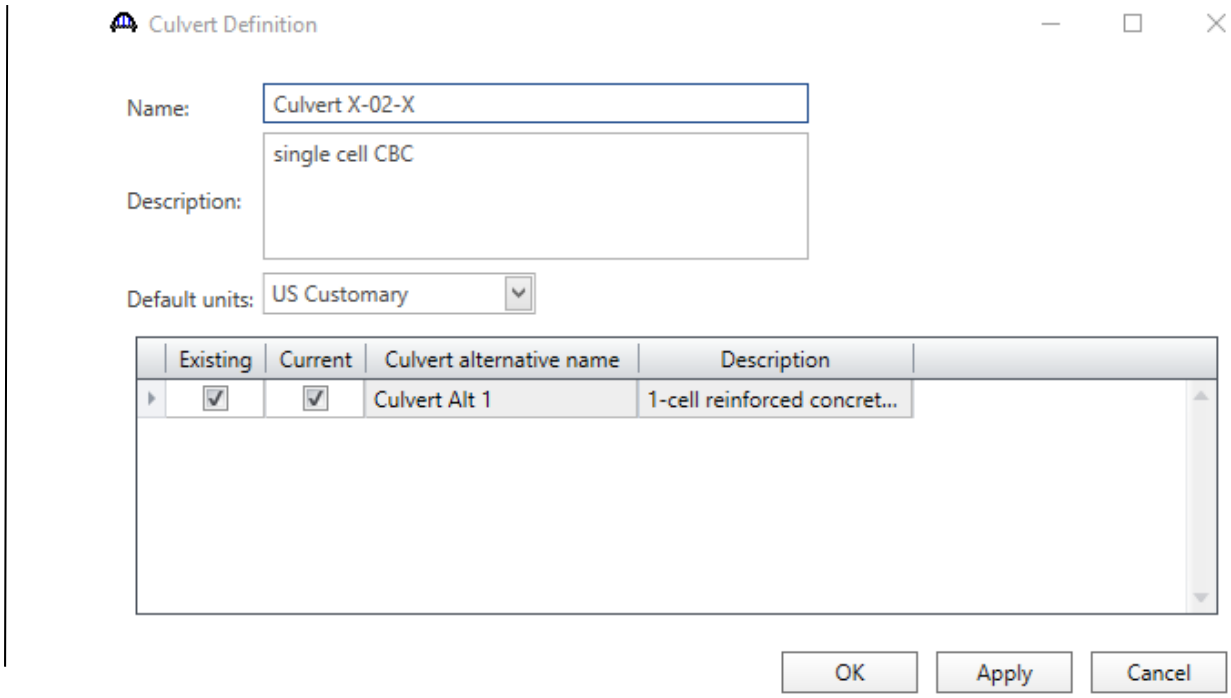


Double-click on the Soil folder to create a new soil material. Click on the Copy from Library button to copy the Standard Soil 1 material to the bridge.



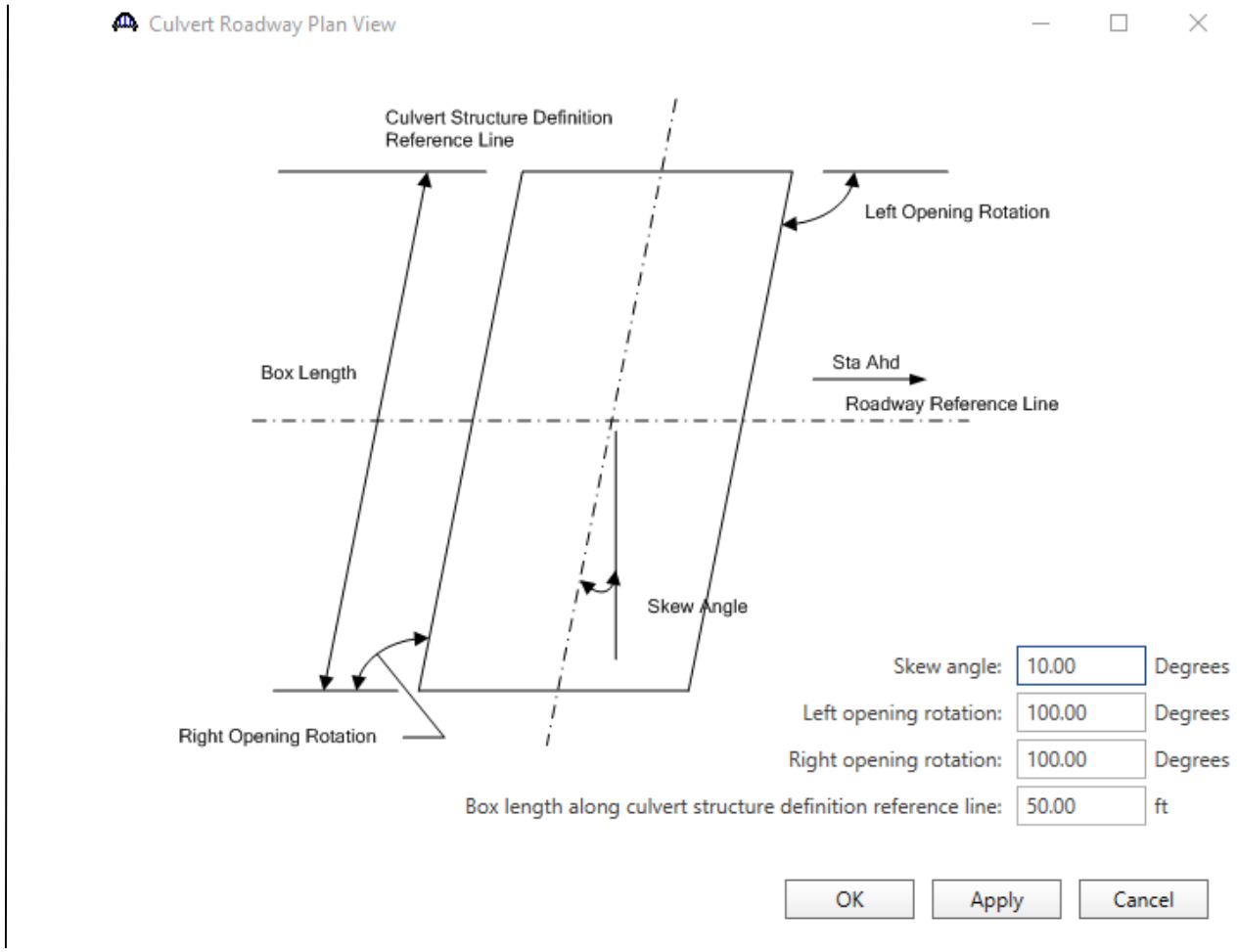
Standard Soil 1 for LFD and LRFD Specification.
Standard Soil 2 for ASD Specification.

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.

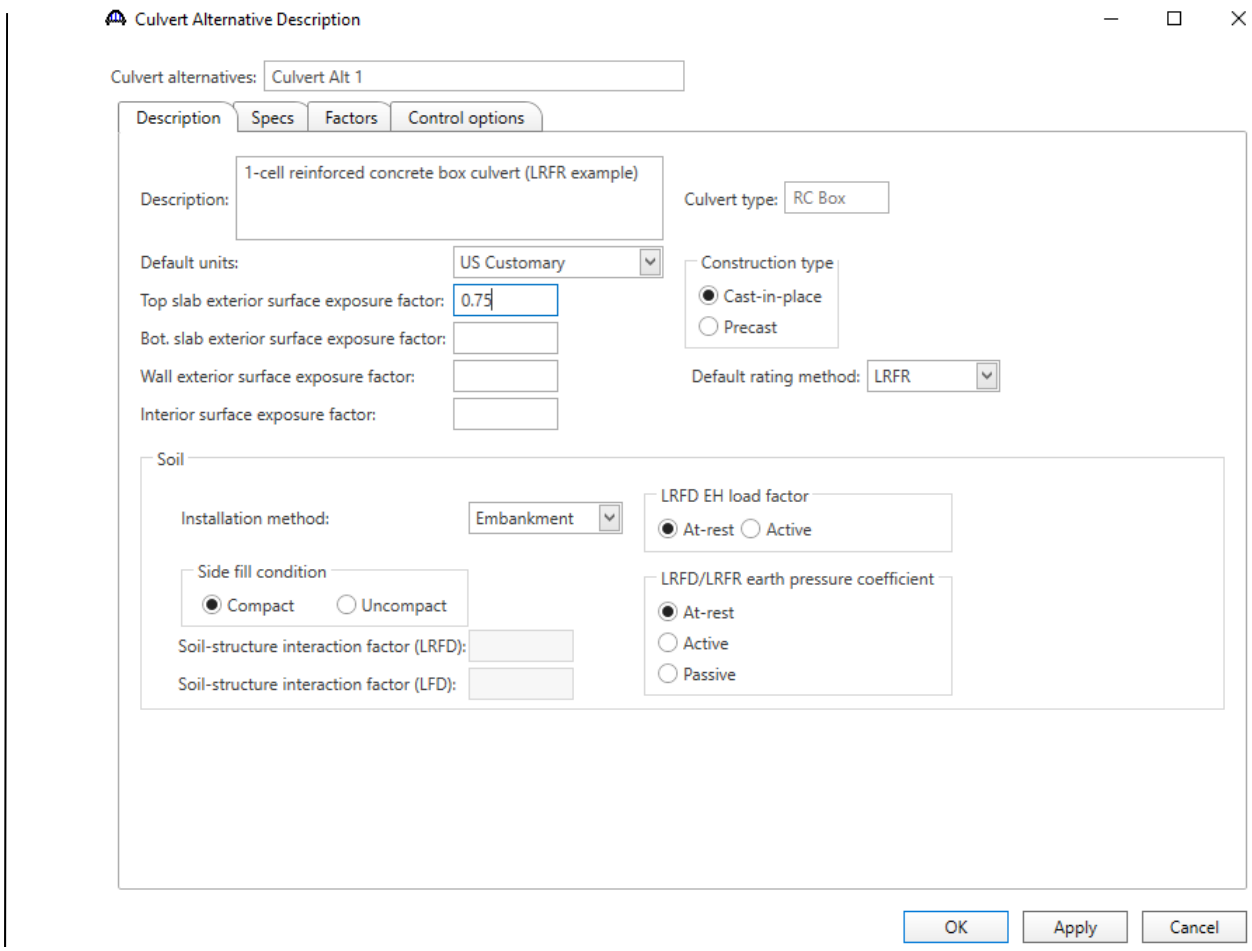


Expand the tree for Culvert Definition X-02-X.

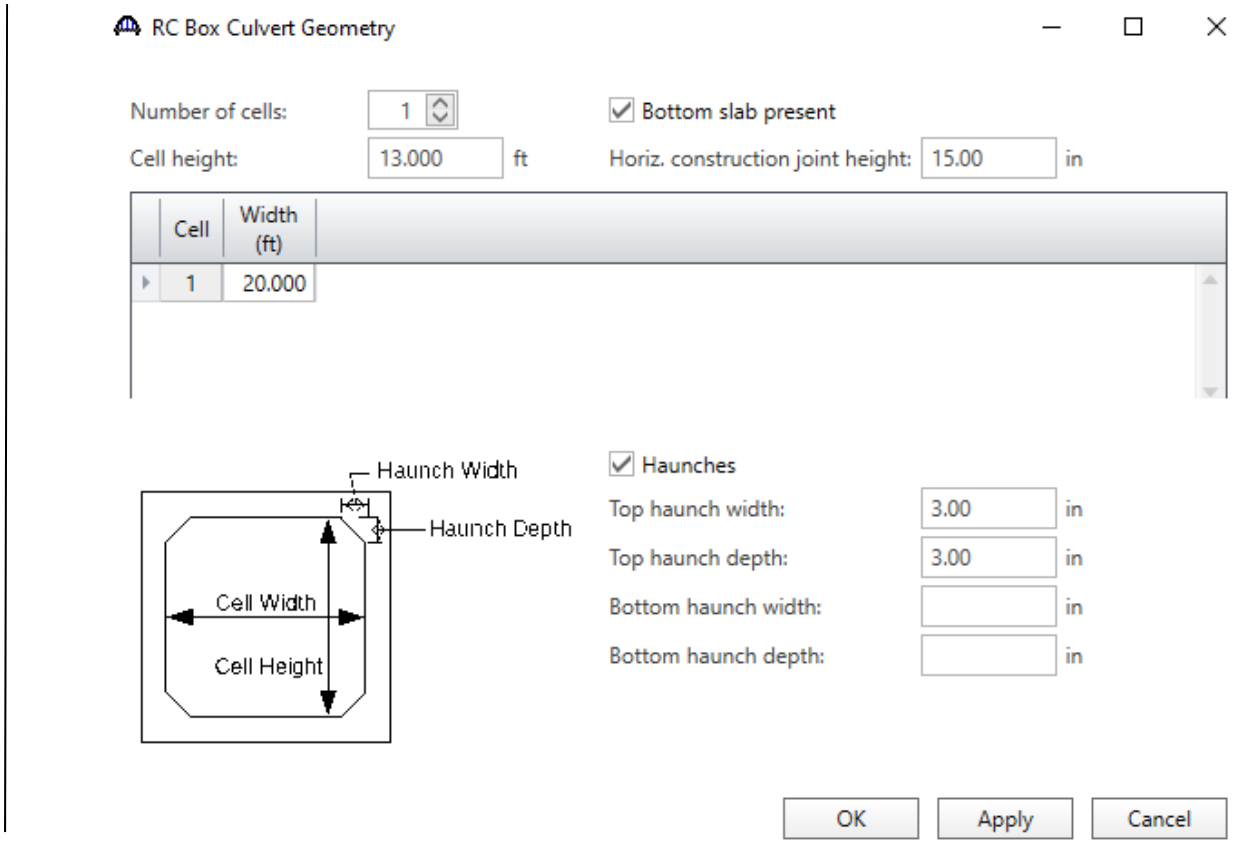
Double-click on the Roadway Plan View to enter the skew angles as shown below.



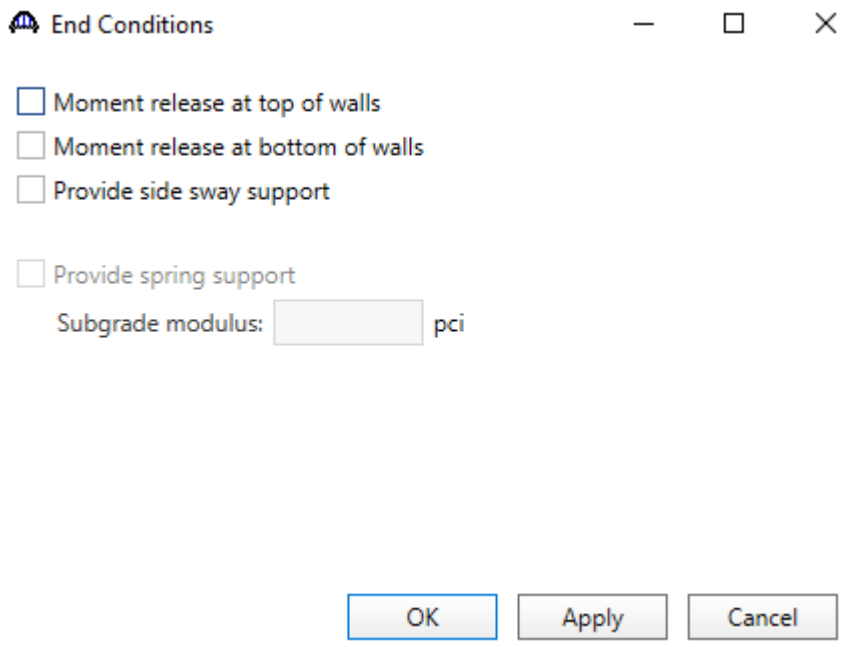
Double-click on the CULVERT ALTERNATIVES folder to create a new culvert alternative for Culvert X-02-X. Enter the data as shown below.



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.

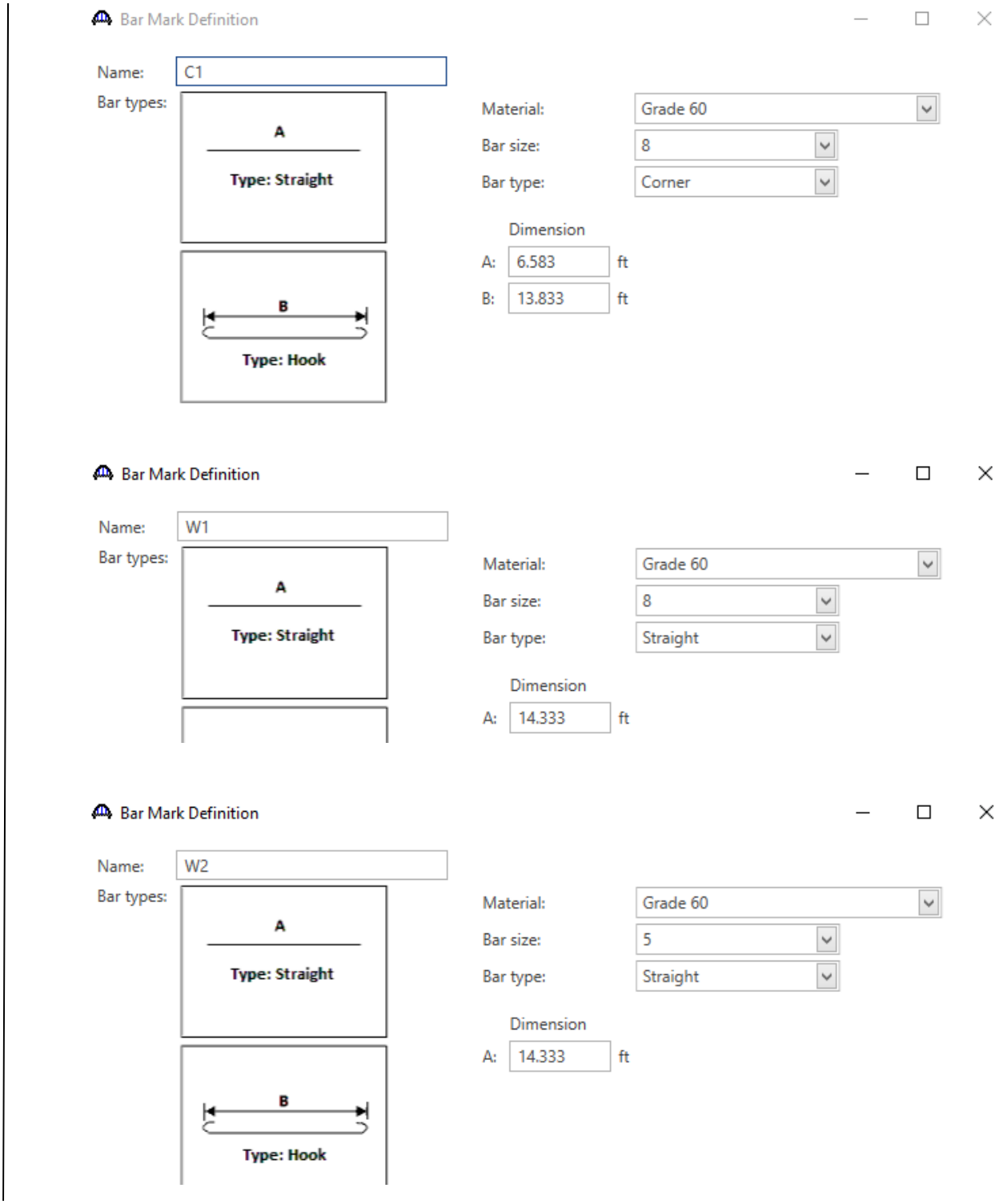


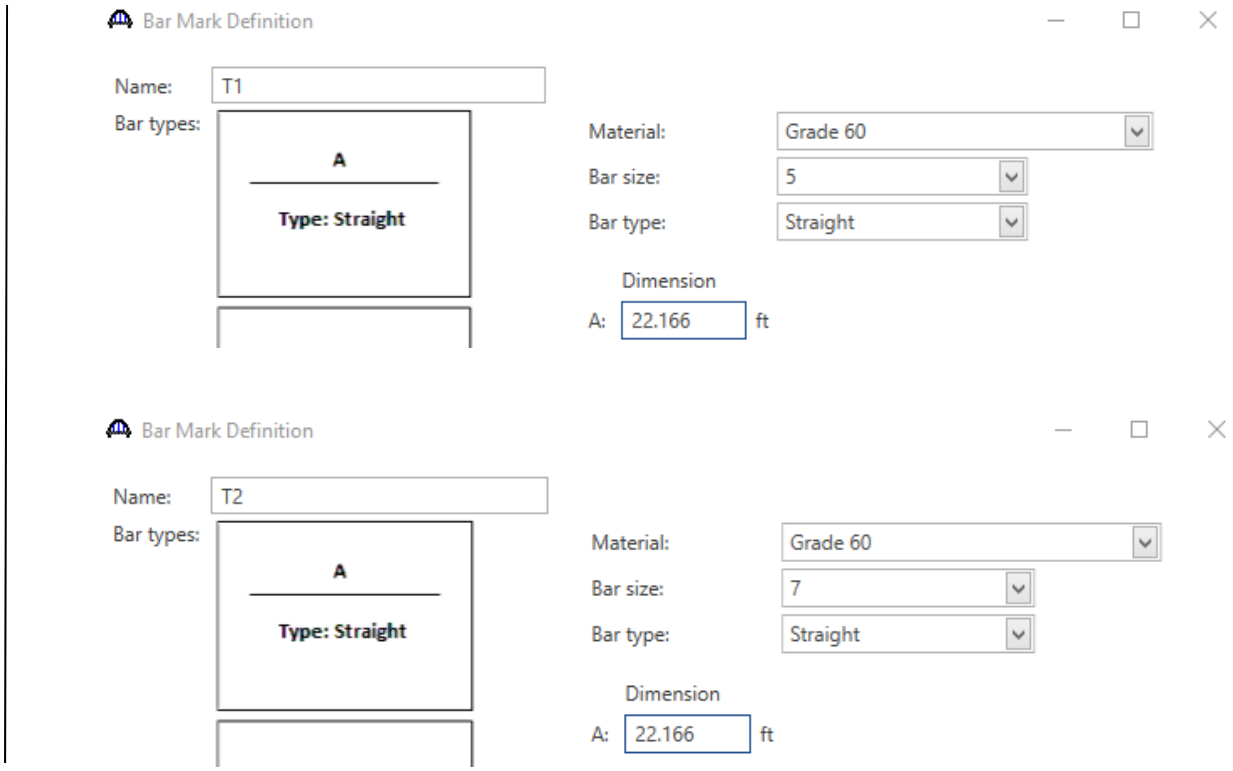
Double-click on End Conditions. Leave uncheck box if reinforcement is rigid. Spring support may be used if subgrade modulus is known. Click Ok to save the data to memory and close the window.



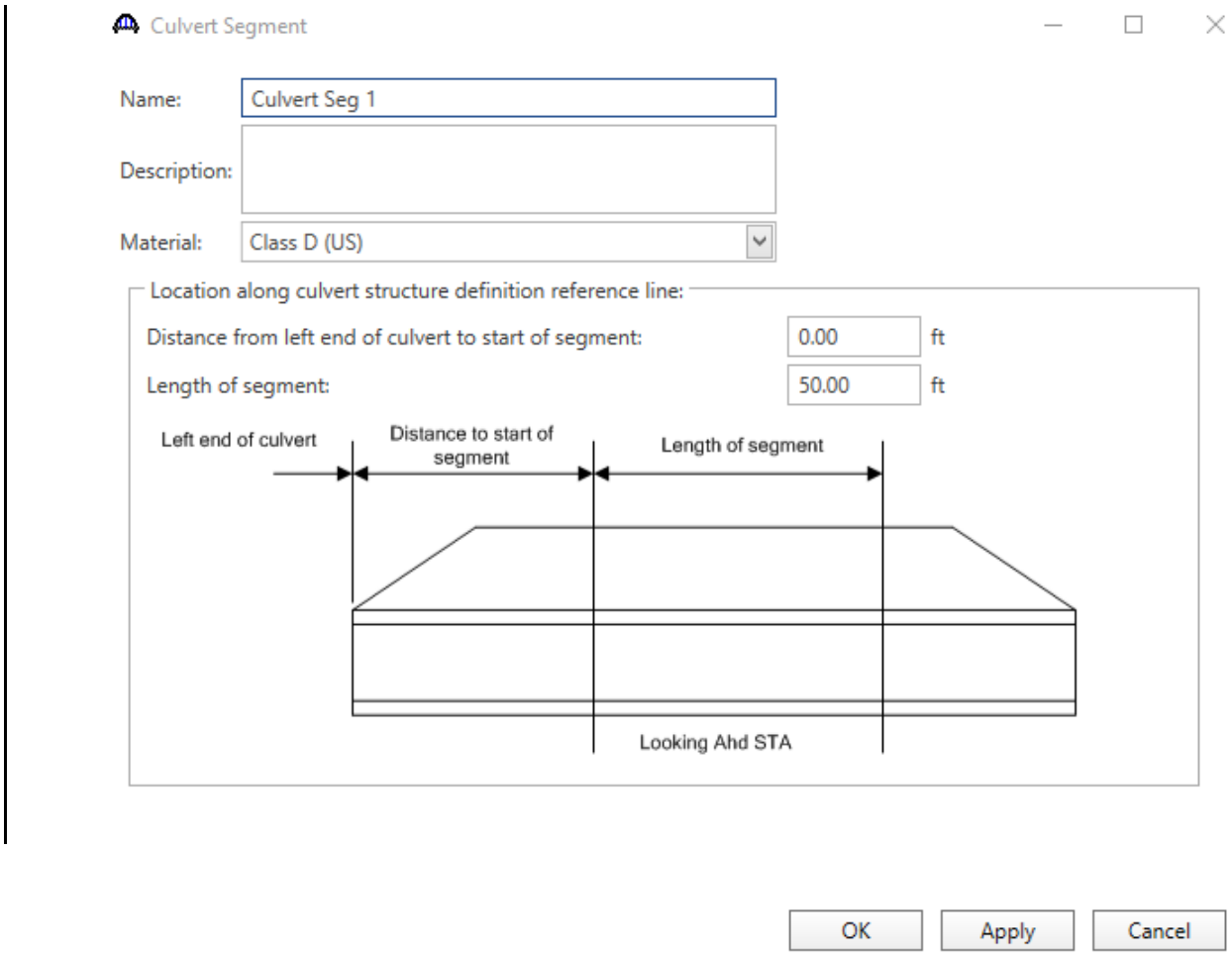
Double-click on the Bar Mark Definitions folder in the tree to create a new bar mark definition for Culvert Alt 1.

Enter the data for C1 as shown below. Click Ok to save the data to memory and close the window. Repeat the process for all bars (W1, W2, T1, and T2) as shown.

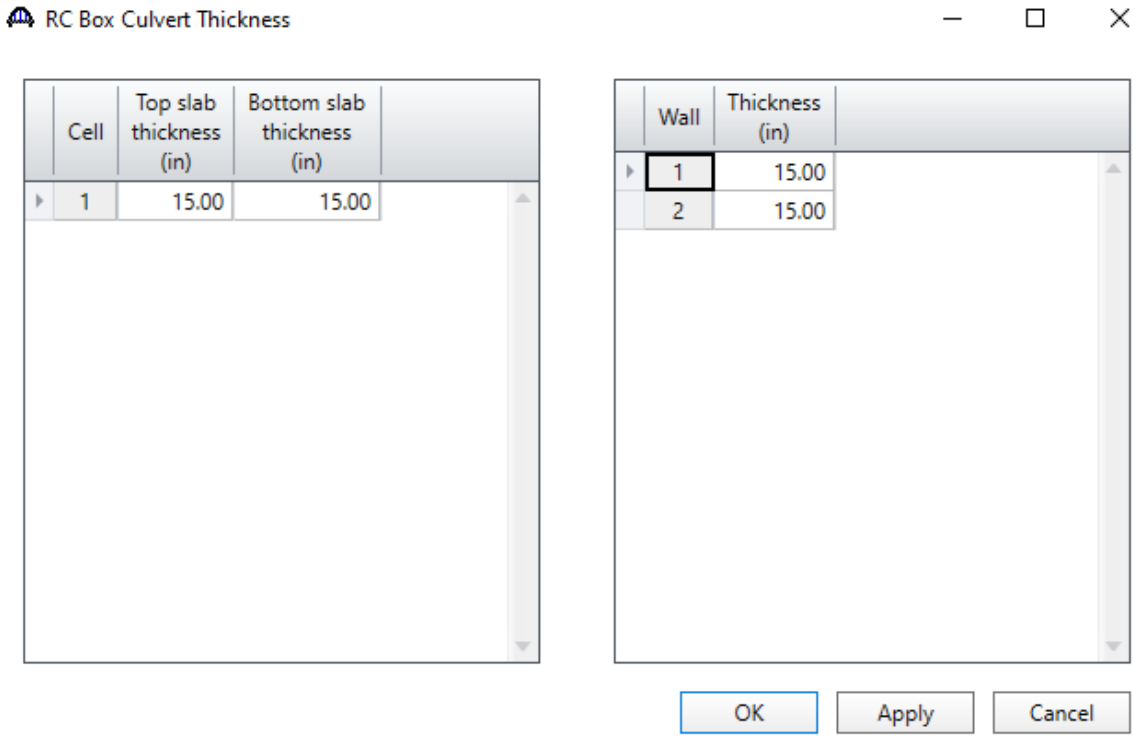



Bar Mark Definition
Name:
T1
Bar types:
A
Type: Straight
Material:
Grade 60
Bar size:
5
Bar type:
Straight
Dimension
A:
22.166
ft
Bar Mark Definition
Name:
T2
Bar types:
A
Type: Straight
Material:
Grade 60
Bar size:
7
Bar type:
Straight
Dimension
A:
22.166
ft

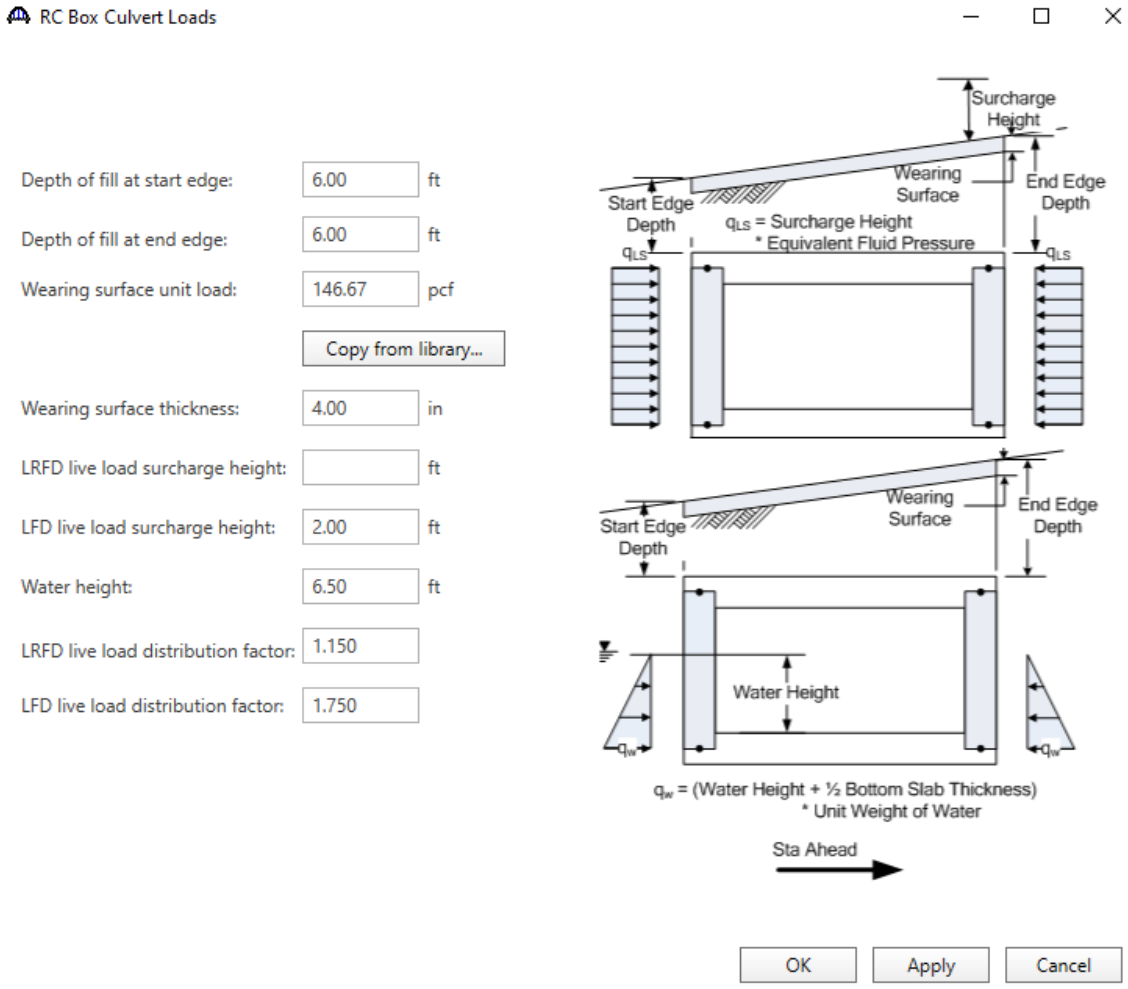
Double-click on the CULVERT SEGMENTS folder to create a new culvert segment for Culvert Alt 1. A culvert alternative may have one or more culvert segments. Enter the data as show below.



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.

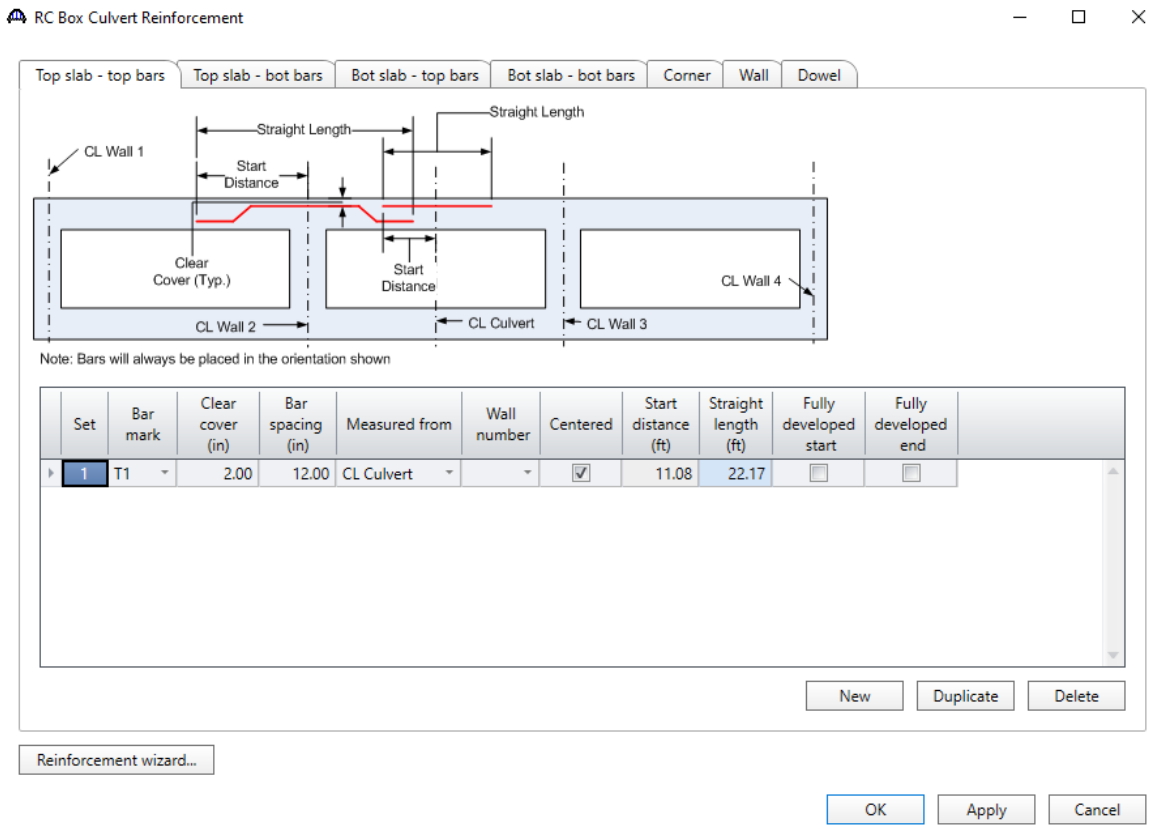


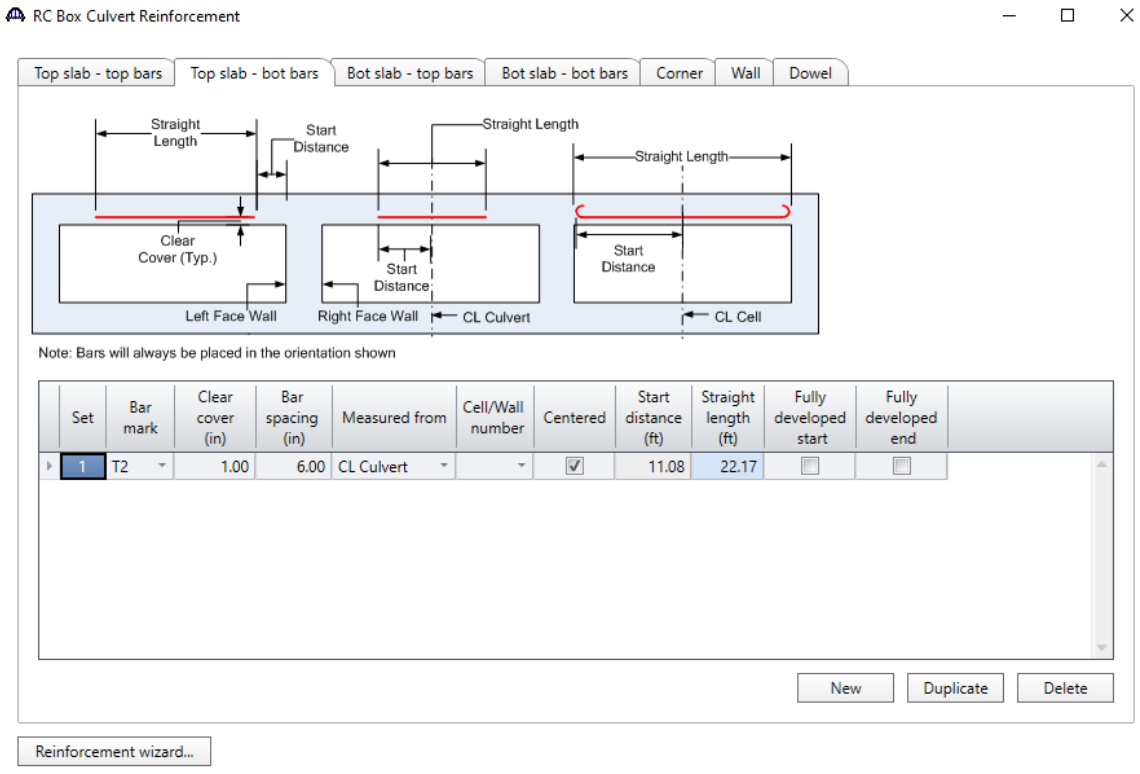
Double-click on RC Box Culvert Loads in the tree. Enter the culvert loads for Culvert Seg 1 as shown below. The wearing surface thickness includes the equivalent for the rail dead load. Click OK to save the data to memory and close the window.

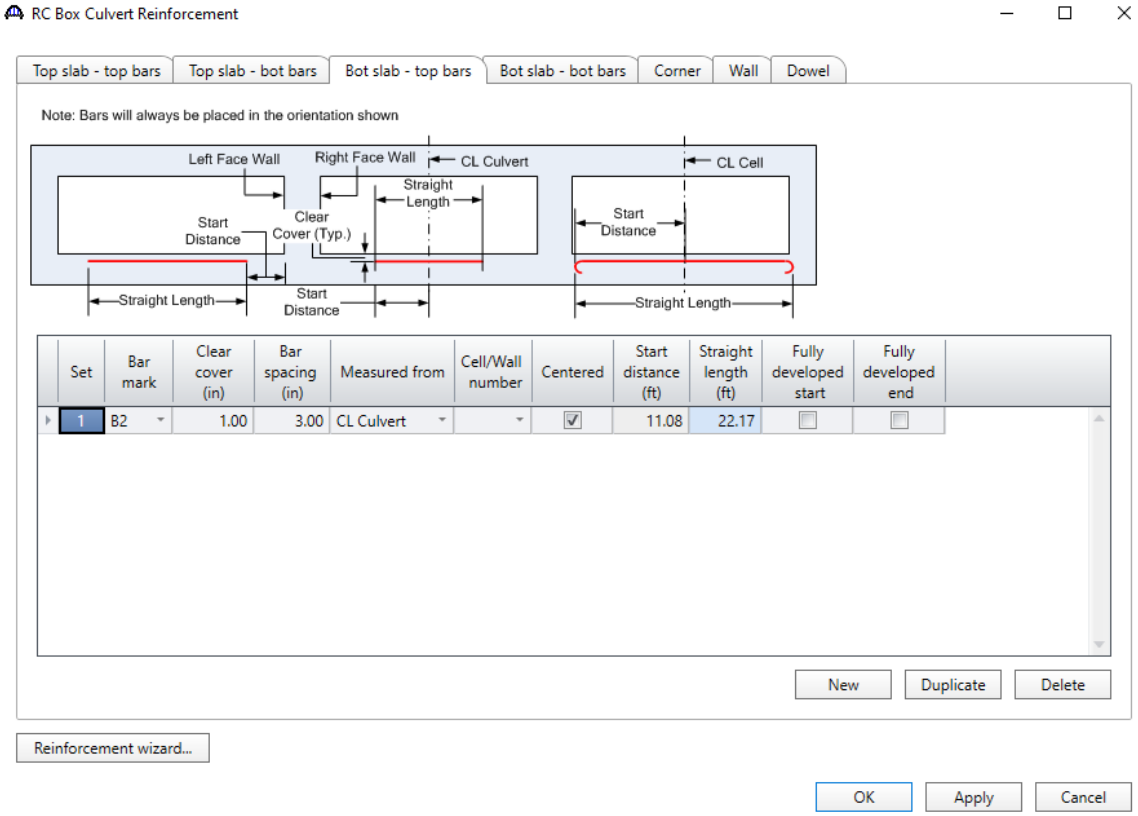


Use water height half the rise of the culvert.

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.



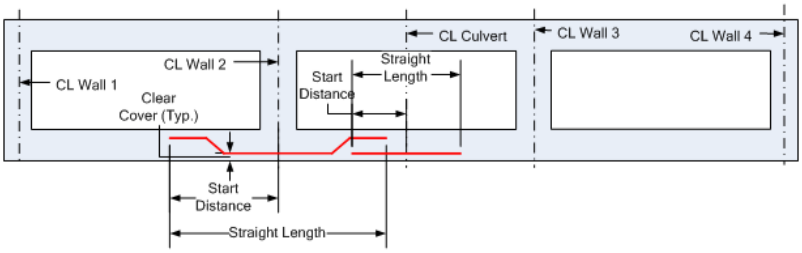

RC Box Culvert Reinforcement
Top slab - top bars
Top slab - bot bars
Bot slab - top bars
Bot slab - bot bars
Corner
Wall
Dowel
Straight Length
Start Distance
Straight Length
Straight Length
Clear Cover (Typ.)
Start Distance
Start Distance
Left Face Wall
Right Face Wall
CL Culvert
CL Cell
Note: Bars will 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
T2
1.00
6.00
CL Culvert
11.08
22.17
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
B2
1.00
3.00
CL Culvert
11.08
22.17
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



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	B1	2.00	6.00	CL Culvert		☑	11.08	22.17	☐	☐

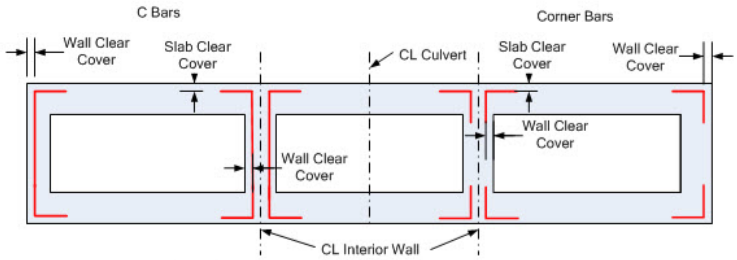
New | Duplicate | Delete

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

Set	Bar mark	Wall clear cover (in)	Slab clear cover (in)	Bar spacing (in)	Location	Wall Number	Fully developed vert	Fully developed horz
1	C1	2.00	2.00	6.00	Top Right	1	☐	☐
2	C1	2.00	2.00	6.00	Top Left	2	☐	☐
3	C1	2.00	2.00	6.00	Bottom Right	1	☐	☐
4	C1	2.00	2.00	6.00	Bottom Left	2	☐	☐

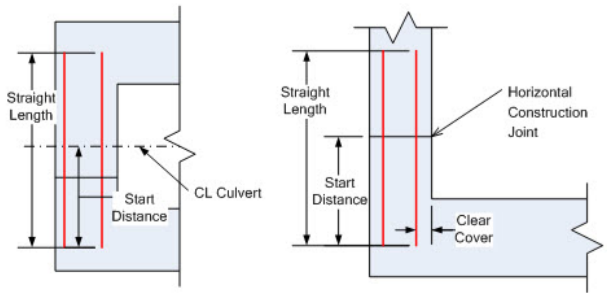
New | Duplicate | Delete

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



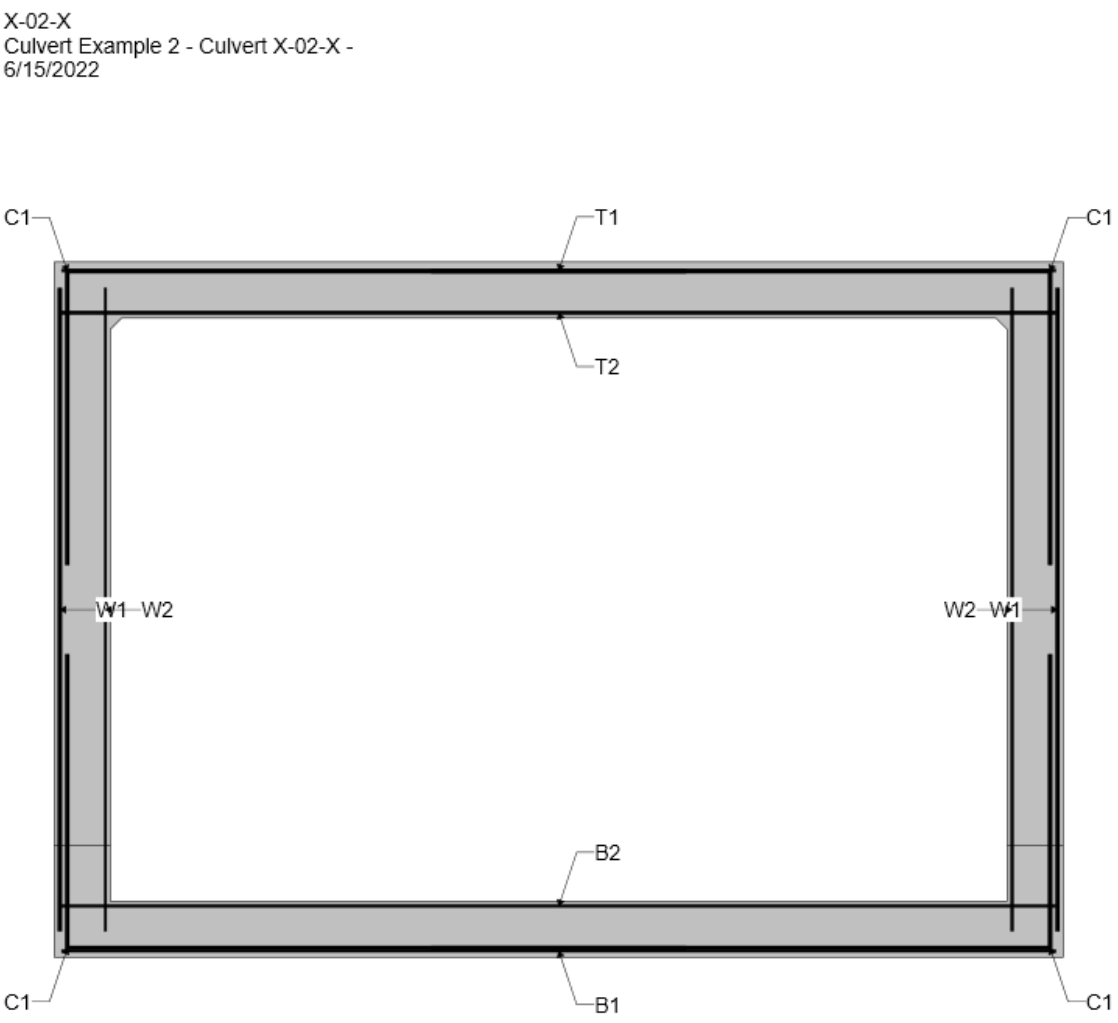
Set	Bar mark	Clear cover (in)	Bar spacing (in)	Location	Wall Number	Measured from	Centered	Start distance (ft)	Straight length (ft)	Fully developed start	Fully developed end
1	W1	13.00	6.00	Right	1	CL Culvert	☑	7.17	14.33	☐	☐
2	W1	13.00	6.00	Left	2	CL Culvert	☑	7.17	14.33	☐	☐
3	W2	1.00	12.00	Right	1	CL Culvert	☑	7.17	14.33	☐	☐
4	W2	1.00	12.00	Left	2	CL Culvert	☑	7.17	14.33	☐	☐

New | Duplicate | Delete

Reinforcement wizard...

OK | Apply | Cancel

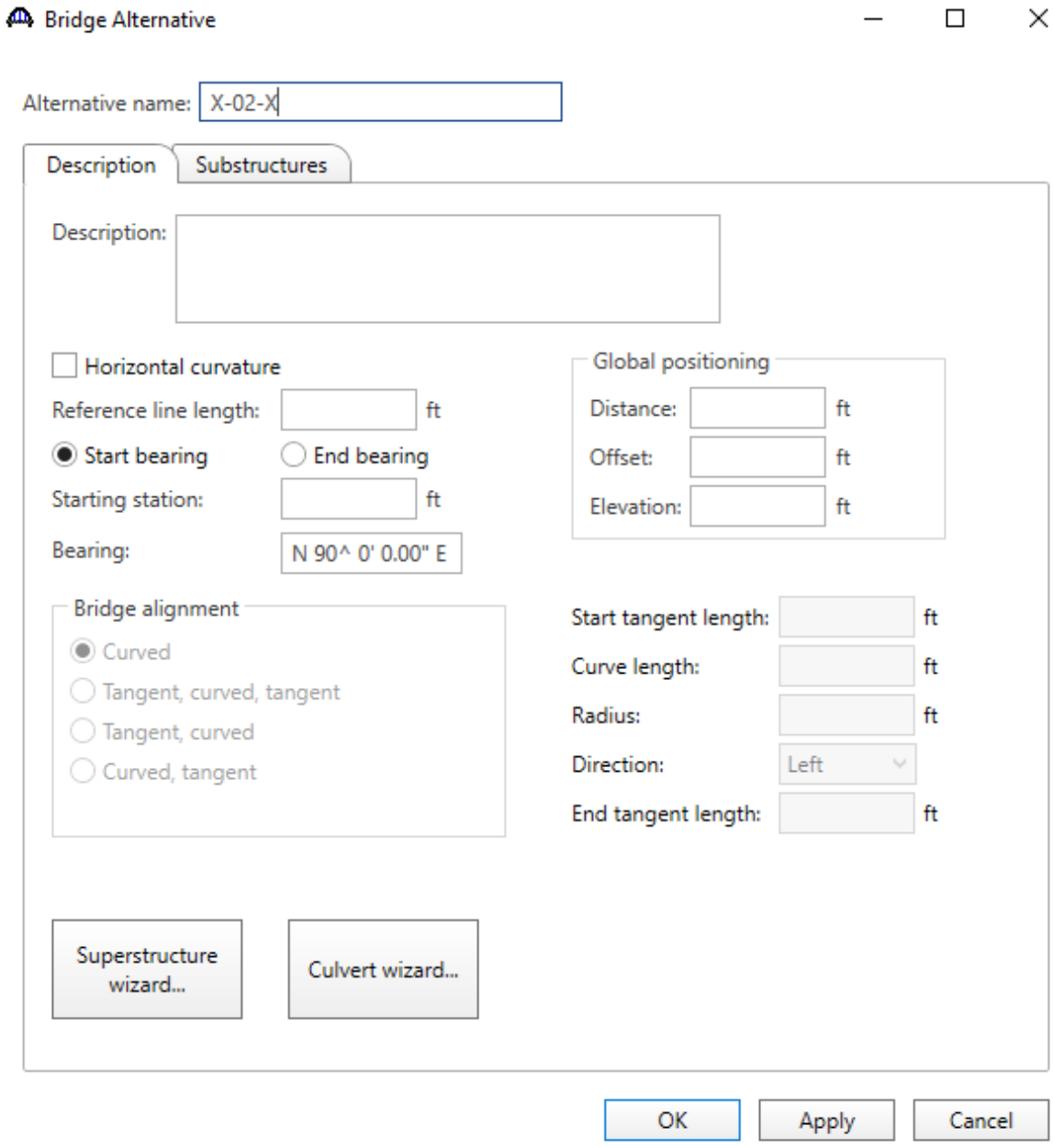
Select Bridge│Schematic to review the reinforcement data.



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

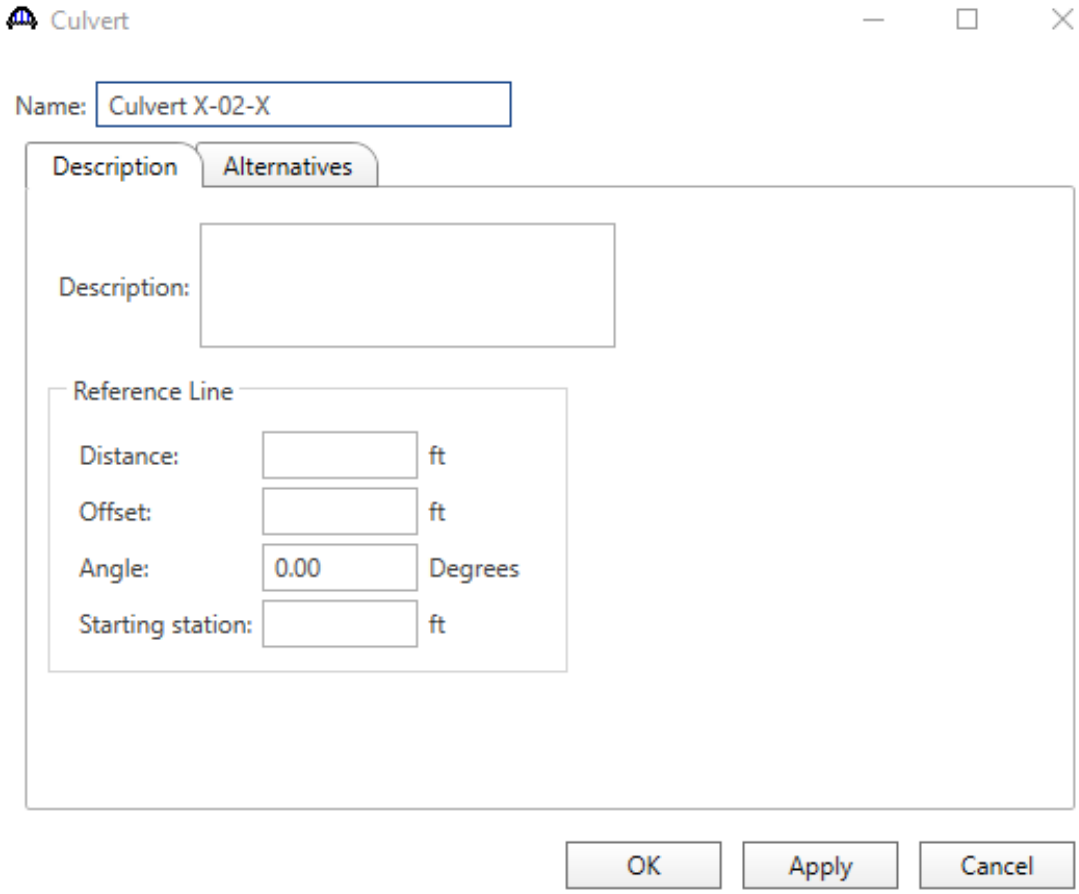
Select File│Save to save the file in BrR.

Double-click on Bridge Alternatives to create an Alternative name. Enter the Bridge Alternative name as show below.



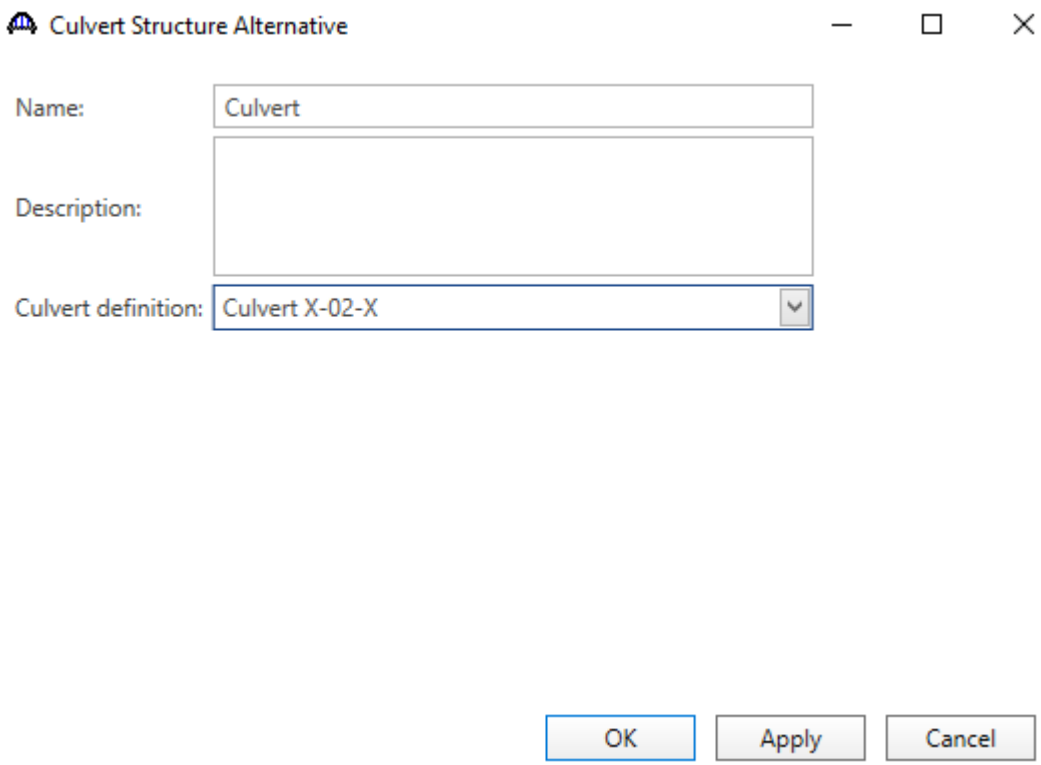
Click Ok to save the data to memory and close the window.

Double-click on Culverts to create a culvert name. Enter the Culvert name as show below.

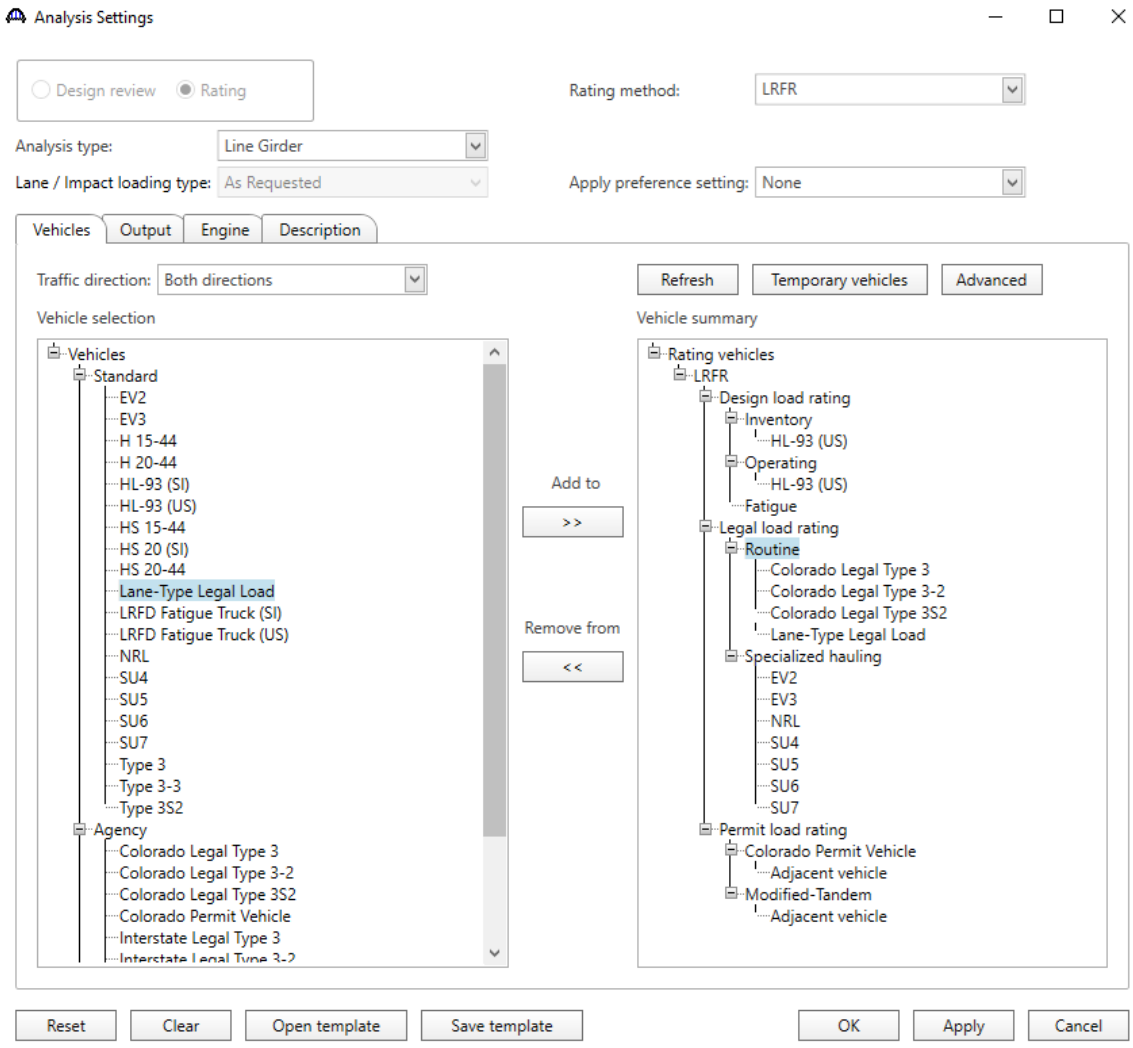


Click Ok to save the data to memory and close the window.

Double-click on Culvert Structure Alternative a name. Enter the Culvert Structure Alternative name as show below.



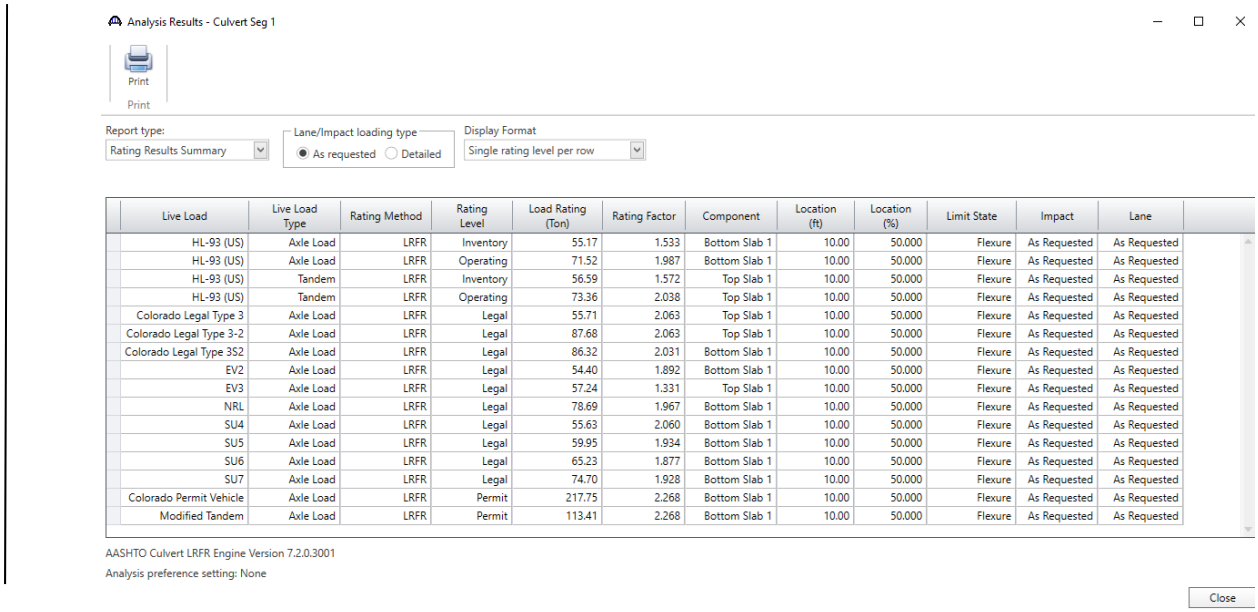
To perform LRFR Design Load Rating, open the Analysis setting window by selecting Bridge | Analysis Settings. Select LRFR as the Rating Method and specify the vehicles.



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	55.17	1.533	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Axle Load	LRFR	Operating	71.52	1.987	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Inventory	56.59	1.572	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Operating	73.36	2.038	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3	Axle Load	LRFR	Legal	55.71	2.063	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3-2	Axle Load	LRFR	Legal	87.68	2.063	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3S2	Axle Load	LRFR	Legal	86.32	2.031	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
EV2	Axle Load	LRFR	Legal	54.40	1.892	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
EV3	Axle Load	LRFR	Legal	57.24	1.331	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
NRL	Axle Load	LRFR	Legal	78.69	1.967	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU4	Axle Load	LRFR	Legal	55.63	2.060	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU5	Axle Load	LRFR	Legal	59.95	1.934	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU6	Axle Load	LRFR	Legal	65.23	1.877	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU7	Axle Load	LRFR	Legal	74.70	1.928	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Permit Vehicle	Axle Load	LRFR	Permit	217.75	2.268	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Modified Tandem	Axle Load	LRFR	Permit	113.41	2.268	Bottom Slab 1	10.00	50.000	Flexure	As Requested	As Requested

Fill out the Rating Summary Sheet using the policies and guidelines in the Bridge Rating Manual, Section 1.

COLORADO DEPARTMENT OF TRANSPORTATION
LOAD & RESISTANCE FACTOR RATING SUMMARY

Rated using:
Asphalt thickness: 4 in.
☑ Colorado legal loads ☐ Interstate legal loads
☑ Multi-lane for Legal & Permit Vehicles ☐ Single lane for Legal & Permit Vehicles

Structure #	X-02-X
State Highway #	US X
Batch I.D.	XXXX
Structure Type	CBC
Parallel Structure #	NA

Structural Member	CBC				
	Rating Factor				
Inventory	1.53				
Operating	1.98				
	Tons				
Type 3 truck	55.7				
Type 3S2 truck	86.3				
Type 3-2 truck	87.6				
Type SU4 truck (27T)	55.6				
Type SU5 truck (31T)	59.9				
Type SU6 truck (35T)	65.2				
Type SU7 truck (39T)	74.7				
NRL (40T)	78.6				
Lane-Type Legal	199.0				
EV2 (28.75T)	54.47				
EV3 (43T)	57.2				
Permit Truck (96T)	217.7				
Modified Tandem (50T)	113.4				

Comments:

Total structure length (face to face of end wall) = 50'-0"
Fill height 6'-0" ; Asphalt 4 inch
NBI Item 62 condition state level = 8 ; Plans available = Yes
Load induced damage present = No ; Pending essential repairs = No
Damage that has a direct effect on load rating = No
Color Code = White
Rate with BrR v7.2.0.3001 Culvert Engine

PE Seal

Rated by: (Print name and sign) Date: Checked by: (Print name and sign) Date:

CDOT Staff Bridge - LRFR 02/2019