14-1 INTRODUCTION TO RATING CONCRETE BOX CULVERTS

This section covers the rating of cast-in-place (CIP) concrete and pre-cast box culverts. This section does not cover flexible culverts or corrugated metal pipes. 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 flexible culverts is discussed in Section 14A.

When there are no plans available for the concrete box culverts being rated, the requirements in Subsection 8-4 and Subsection 14-2 III "Guidelines for using Engineering Judgement / Visual Rating" 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 – Rubber Arch Culvert
SAC – Steel Arch Culvert
TBC – Timber Box Culvert
TTC – Timber Culvert

14-2 POLICIES AND GUIDELINES FOR RATING CONCRETE BOX CULVERTS

I. General

A. Load and Resistance Factor Rating Method (LRFR) shall be used for all re-rating and new ratings of culverts designed with Load and Resistance Factor Design (LRFD). Load Factor Rating Method (LFR) shall be used for rating culverts that were designed with Load Factor Design (LFD) or Allowable Stress Design (ASD). If the CBC ratings require no posting, color code and the Inventory rating factor is ≥ 1, a CBC designed using the LFD method can be rated using LRFR.

B. All major concrete box culverts (i.e. length greater than 20' between inside faces of outside walls) shall be rated by the latest version of AASHTOWARE BrR program or one acceptable to the CDOT Bridge Branch. Programs other than AASHTOWARE BrR must be approved in advance by the Staff Bridge. If CDOT standard plans (i.e. M-601-1, M-601-2 and M-601-3) are used in the design, the rating values shown in the standard plans shall be used to populate the Rating Summary Sheet. LRFR Rating Summary Sheets for each type and size of CBC are available and can be provided by Staff Bridge if requested.

C. Inventory and operating rating levels shall be performed for the HS20-44 and Alternate Military Vehicle loading when LFR method is used and the HL93 loading when LRFR method is used. Also, ratings for the vehicles defined in the November 24th, 2014 Technical Memorandum "Bridge Load Rating Using Specialized Hauling Vehicles (SHV) and Notional Rating Load (NRL)" shall be provided.

> 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. When the fill height is greater than 5.0 feet and less than 8.0 feet and the CBC shows no signs of distress, CDOT will generally consider the structure to have negligible live load and no live load analysis will be required. A rating summary sheet is required for culverts meeting these criteria. Both the inventory and operating rating shall be coded as 99.9 Metric (110.12 English). The permit vehicle rating shall be left blank and the color code shall be coded as white. The controlling depth of fill shall be recorded on the Rating Summary Sheet with the notation "live load is negligible".

II. 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.

III. 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. Live load contribution through fill will be assumed as per the Bridge Rating Manual section 14-2 (I) 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.

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 8-4 for shallow fill heights and 14-2 for deeper fill heights. 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 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

I. 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, November 24th, 2014 Technical Memorandum "Bridge Load Rating Using Specialized Hauling Vehicles (SHV) and Notional Rating Load (NRL)" and as amended herein.

II. 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 the current version of BrR is preferred.

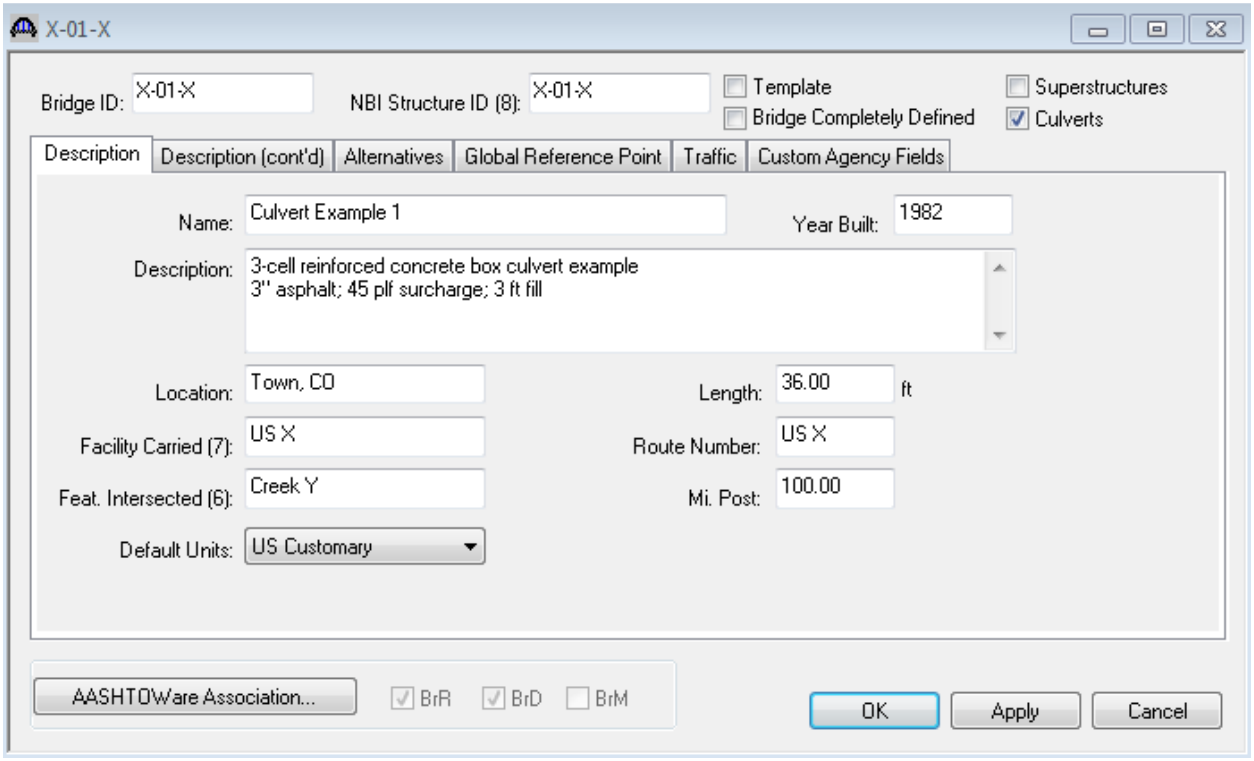
B. When the rating is finalized, the rater shall save the input files in ".xml" format. The file name shall include the structure number of the rated CBC (i.e., O-14-BY.xml). The rating package including input program file, Rating Summary Sheet and necessary computations in pdf shall be transmitted electronically 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 fill. The structure has a 3 inch asphalt overlay. Loading includes a 45 plf load across the structure to account for the rail dead load. This structure is rated using a HS20-44 truck and lane live load, Colorado Permit Vehicle, Alternate Military Vehicle, Colorado Legal Type 3, 3S2, 3-2 vehicles, NRL and SU4 thru SU7 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 and a 45 plf rail load. 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 and SU4 thru SU7 vehicles.

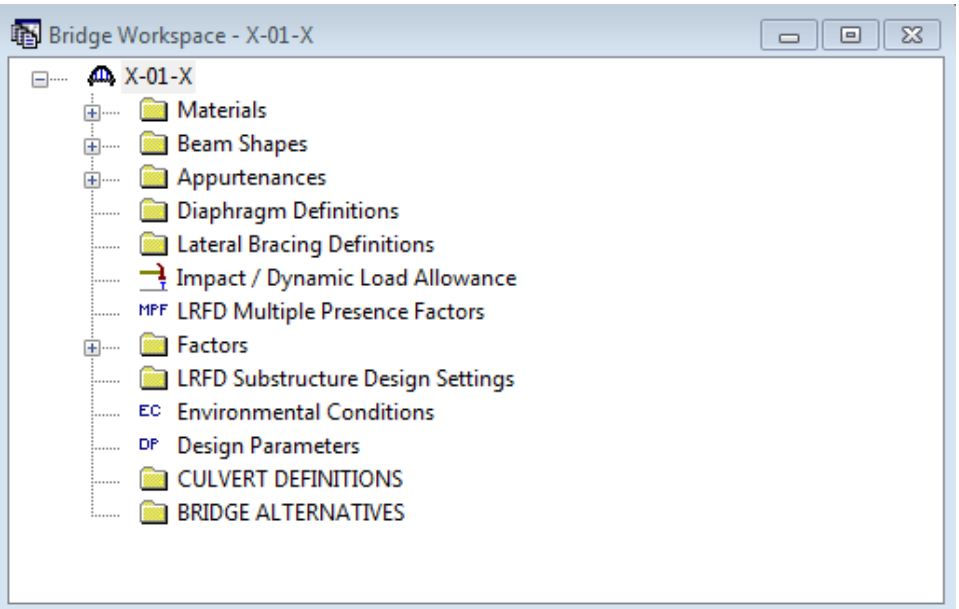
I. **AASHTOWare** BrR Program, Example 1 (LFR) - Structure No. X-01-X

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

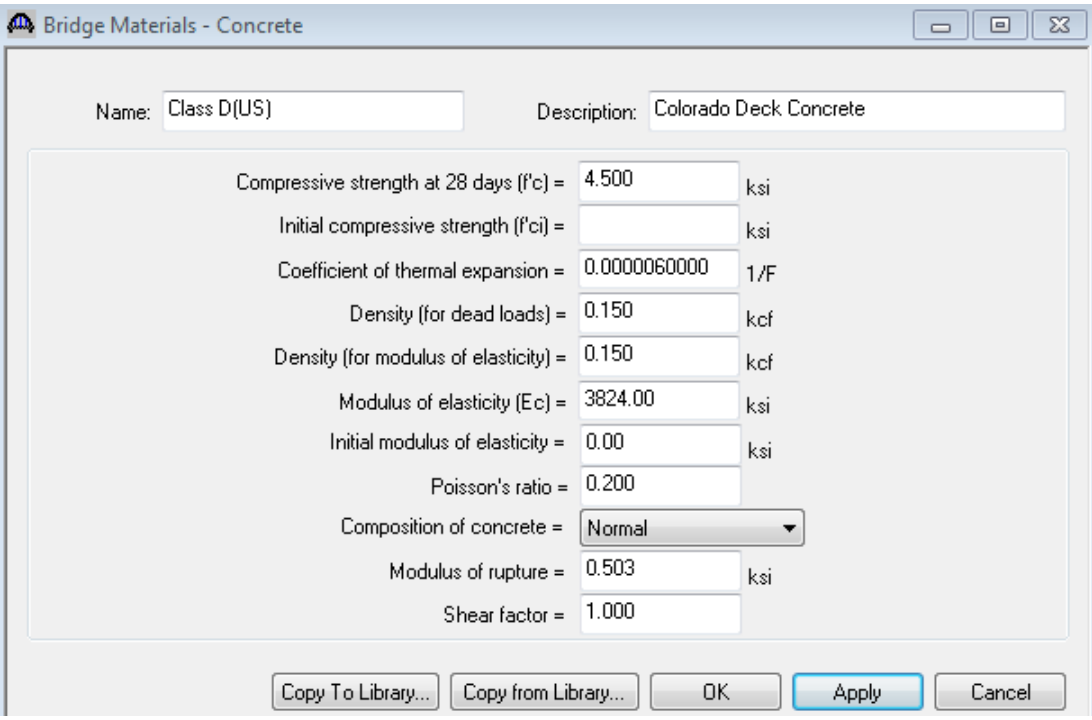


Close the window by clicking OK. This saves the data to memory and closes the window.

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

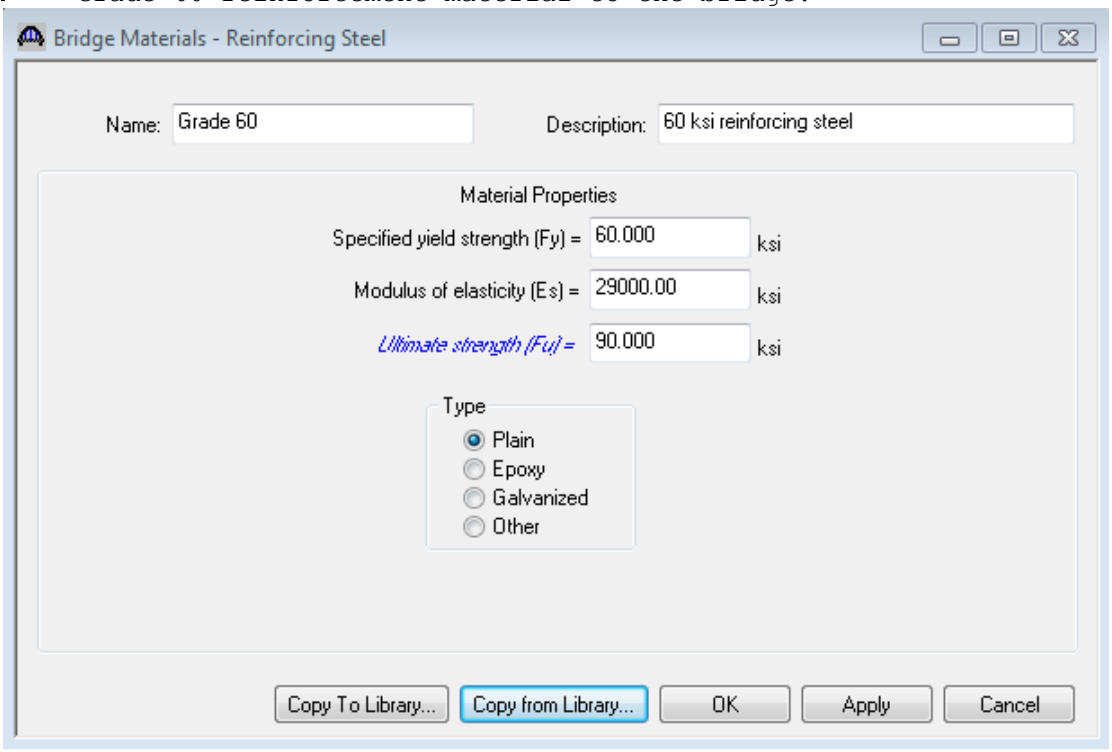


To enter the materials for the culvert, expand the tree for Materials. Double-click on the Concrete folder to create a new concrete material. Enter the following values.

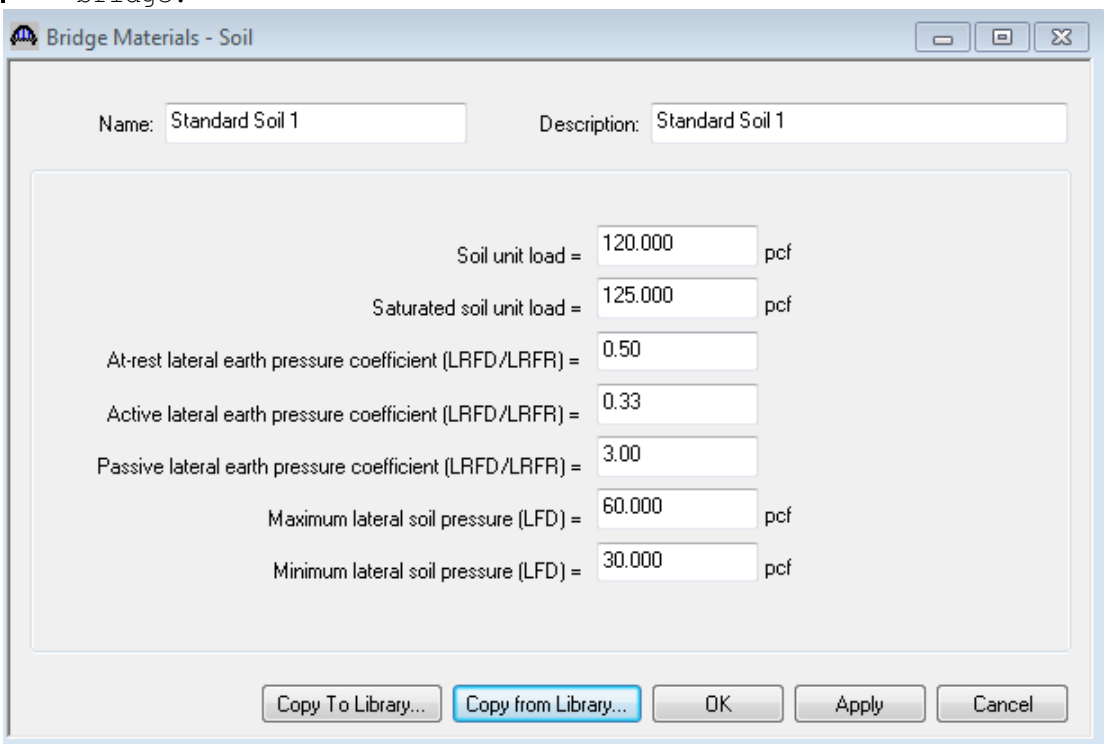


When plans are available, use the minimum concrete strength and yield strength values given in the plans. If plan values are not known, values given in Section 1 of the Bridge Rating Manual for the applicable year of construction may be followed.

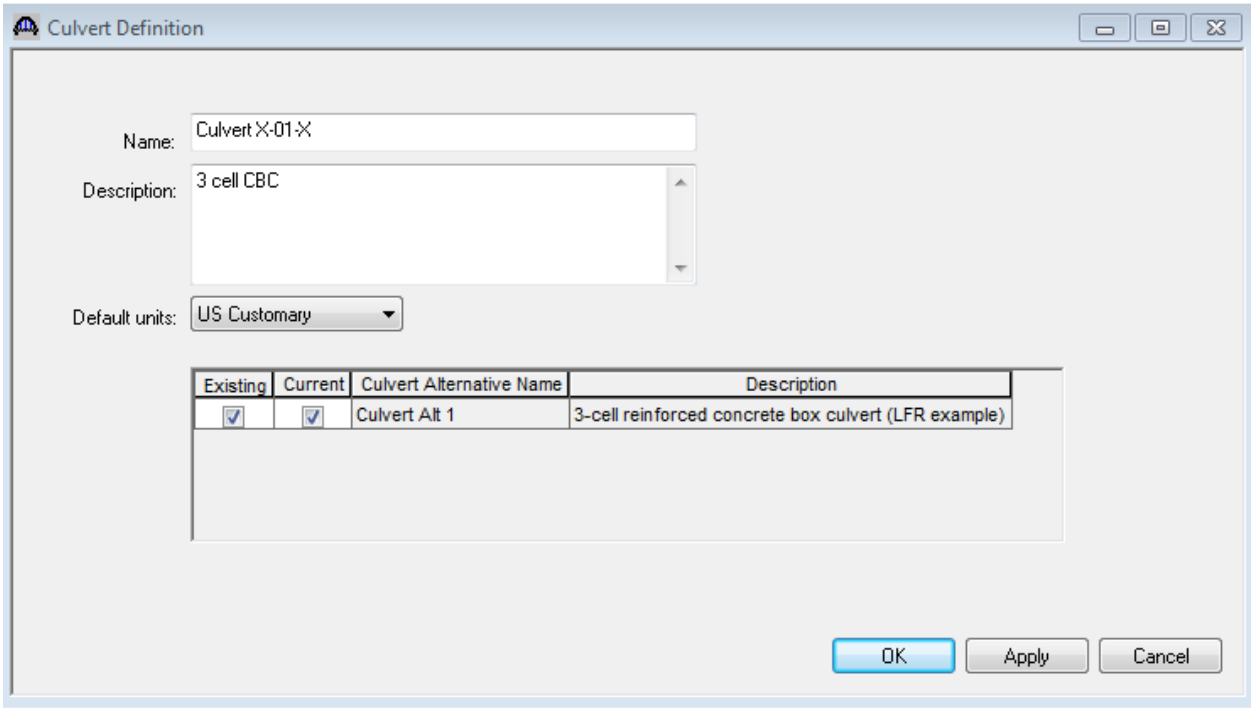
Double-click on the Reinforcing Steel folder to create a new reinforcement material. Click on the Copy from Library button to copy the Grade 60 reinforcement material to the bridge.



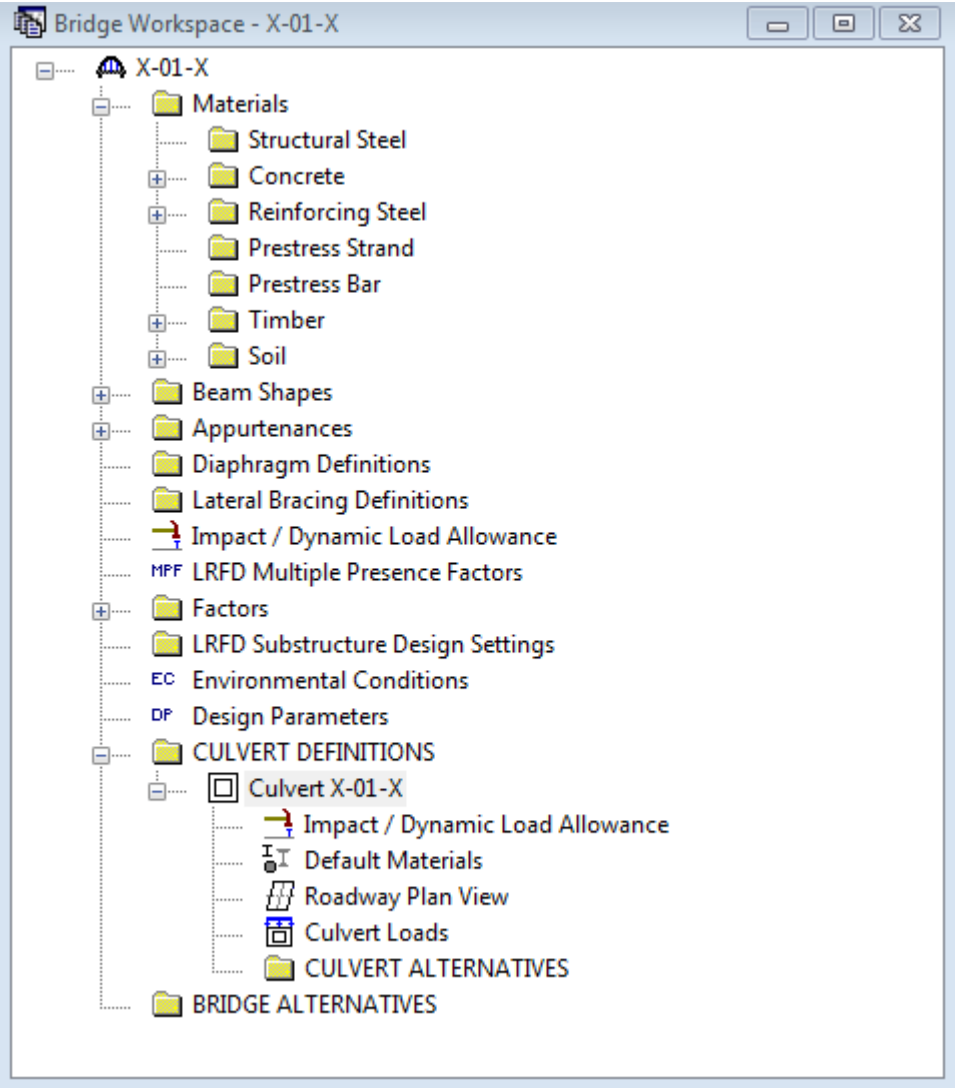
Double-click on the Soil folder to create a new soil material. Click on the Copy from Library button to copy the Standard Soil 1 material to the bridge.



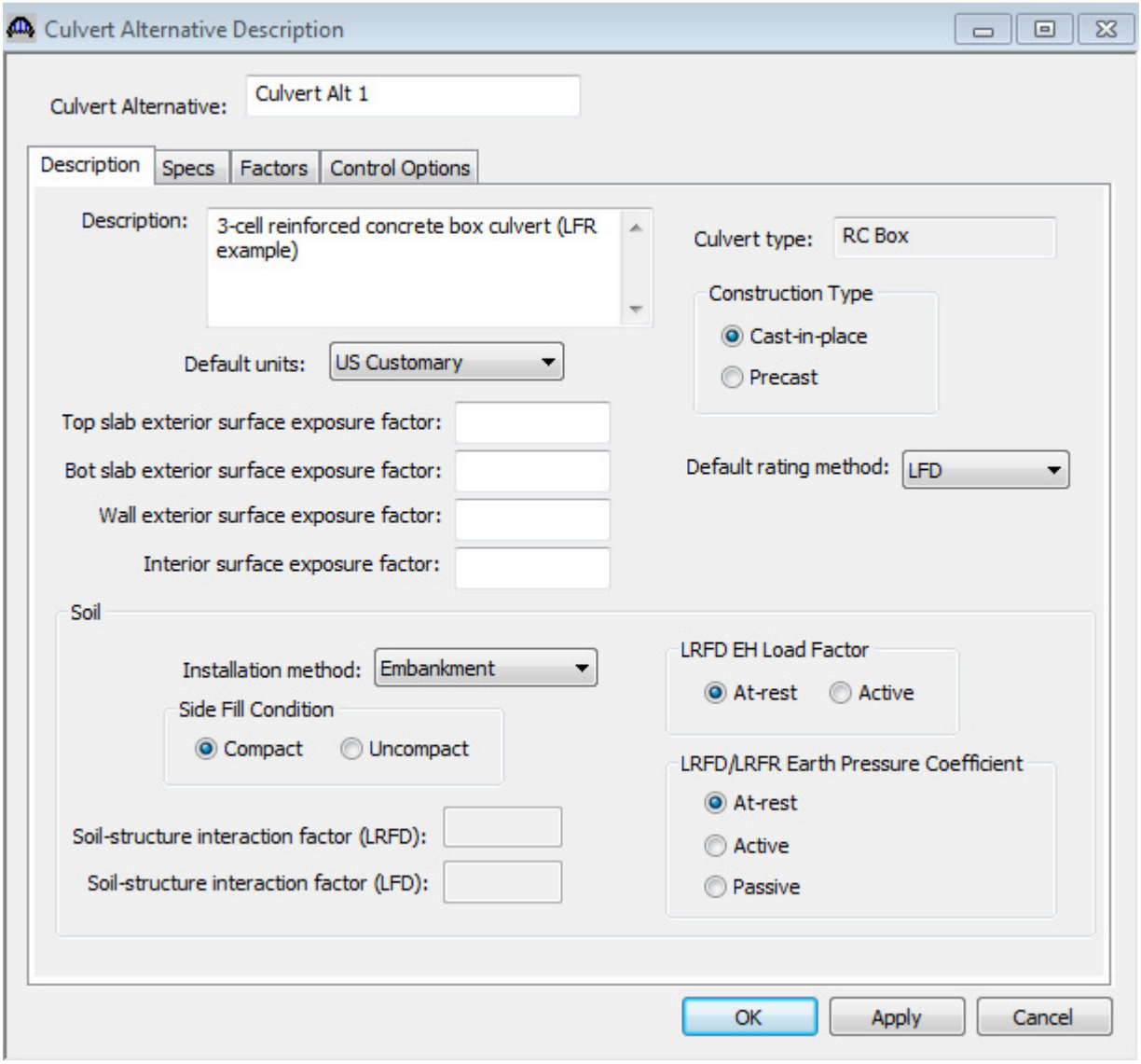
Double-click on the CULVERT DEFINITIONS folder to create a new culvert definition. Enter the Culvert Definition name as show below. The first Culvert Alternative that we create will automatically be assigned as the Existing and Current Culvert Alternative for this Culvert Definition.



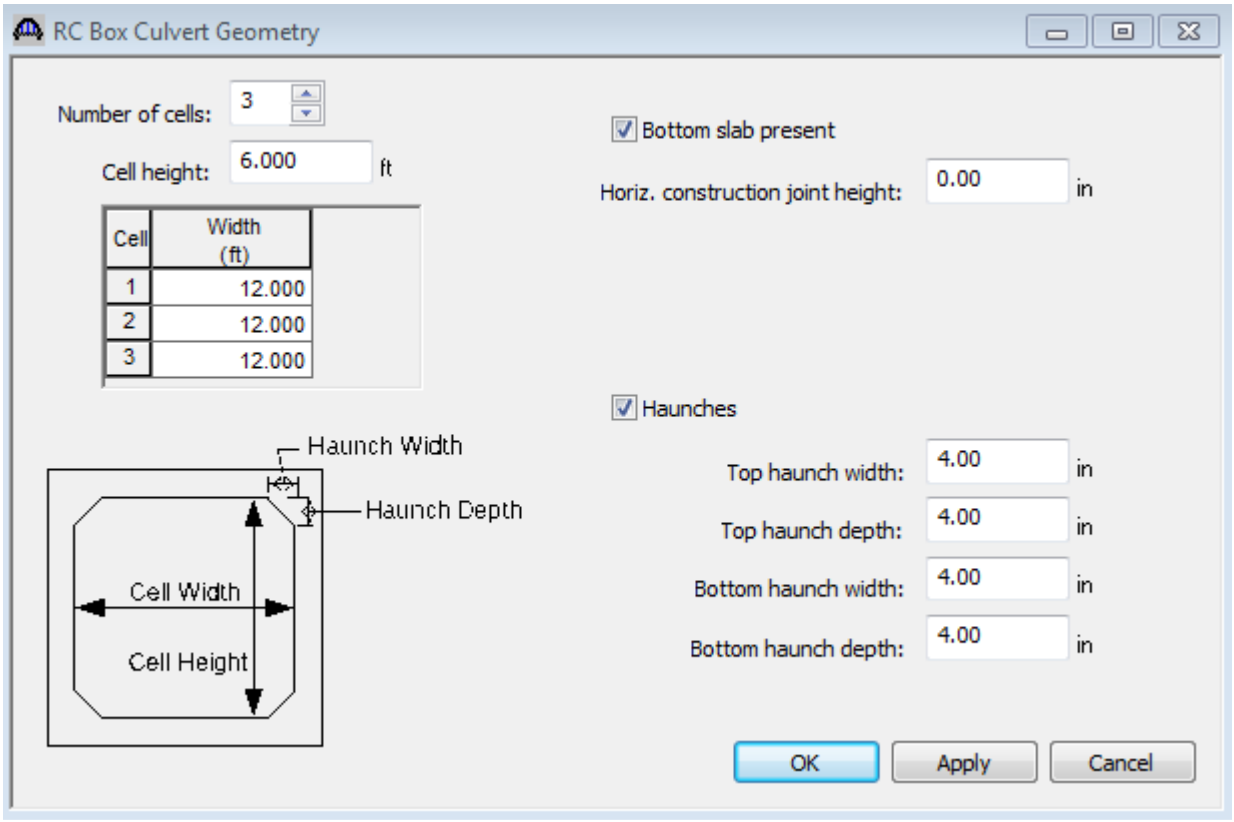
Expand the tree for Culvert Definition X-01-X.



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

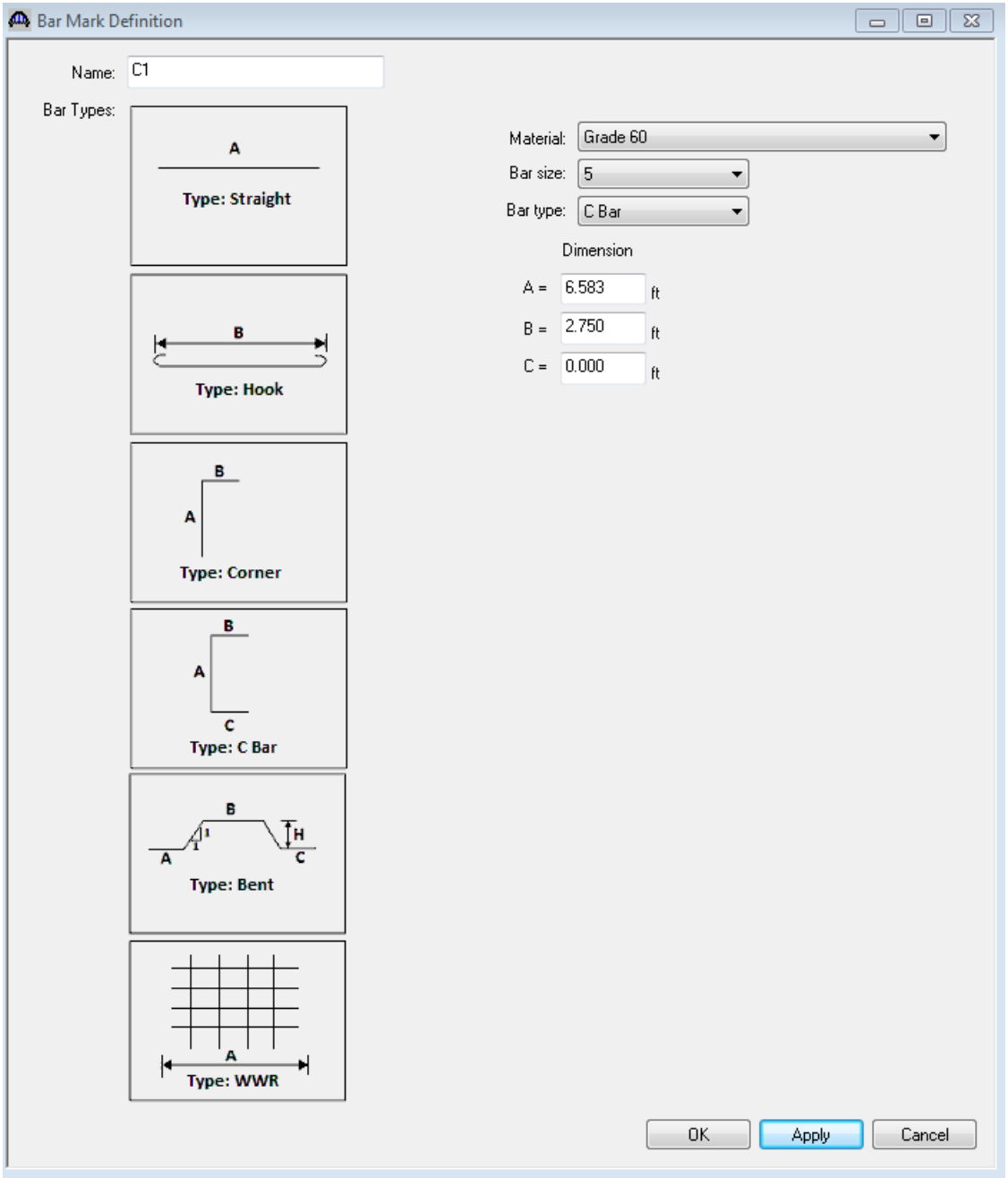


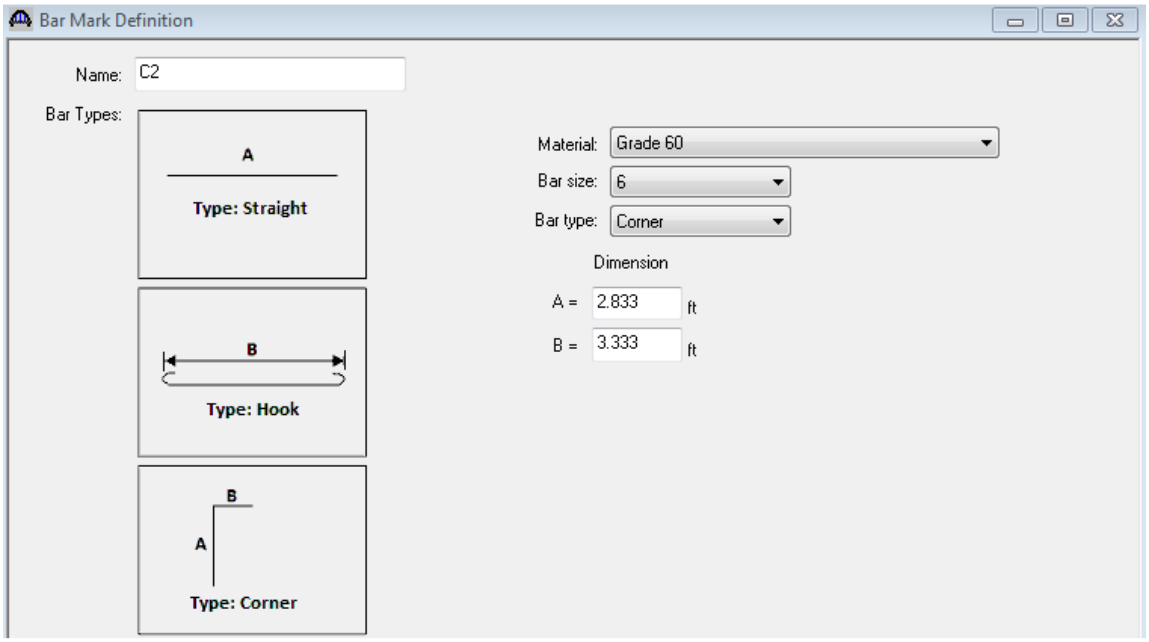
Expand the tree for Culvert Alt 1.
Double-click on RC Box Culvert Geometry in the tree. Enter the data as shown below. Click Ok to save the data to memory and close the window.

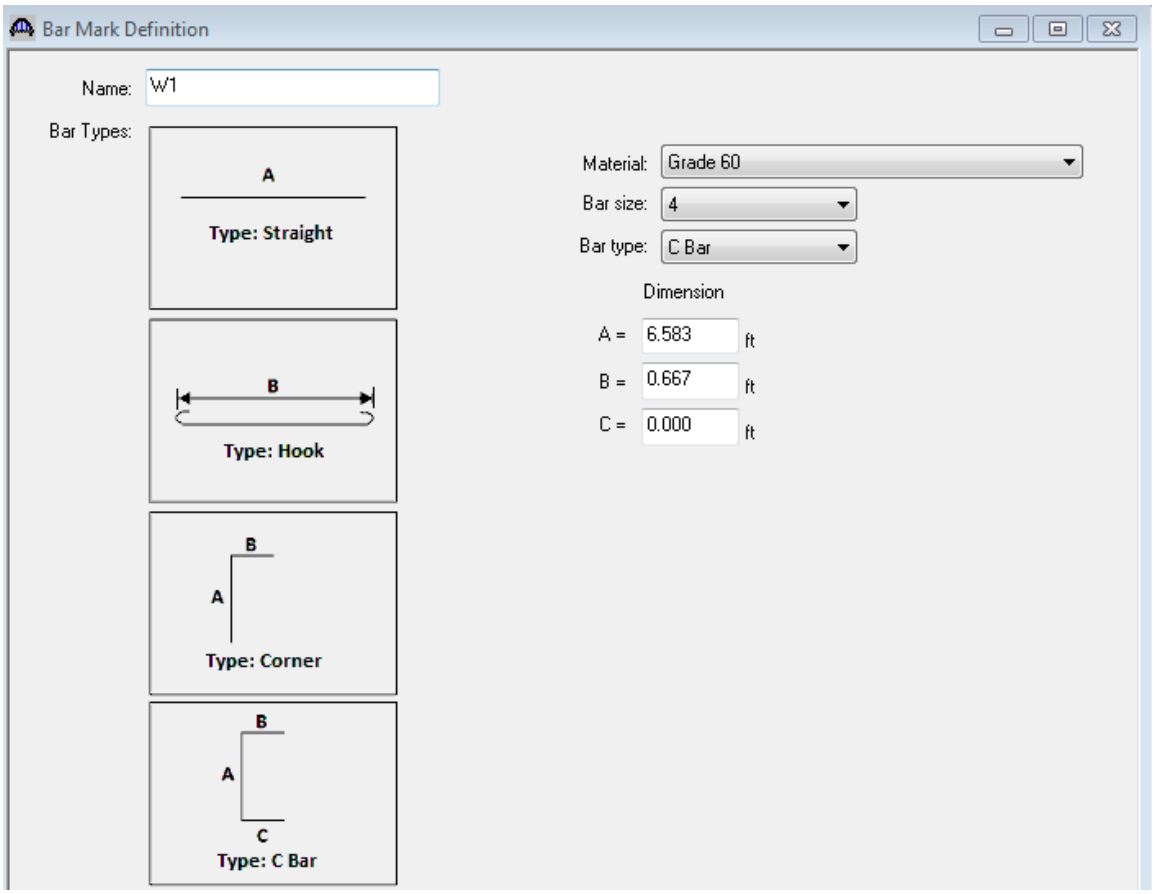


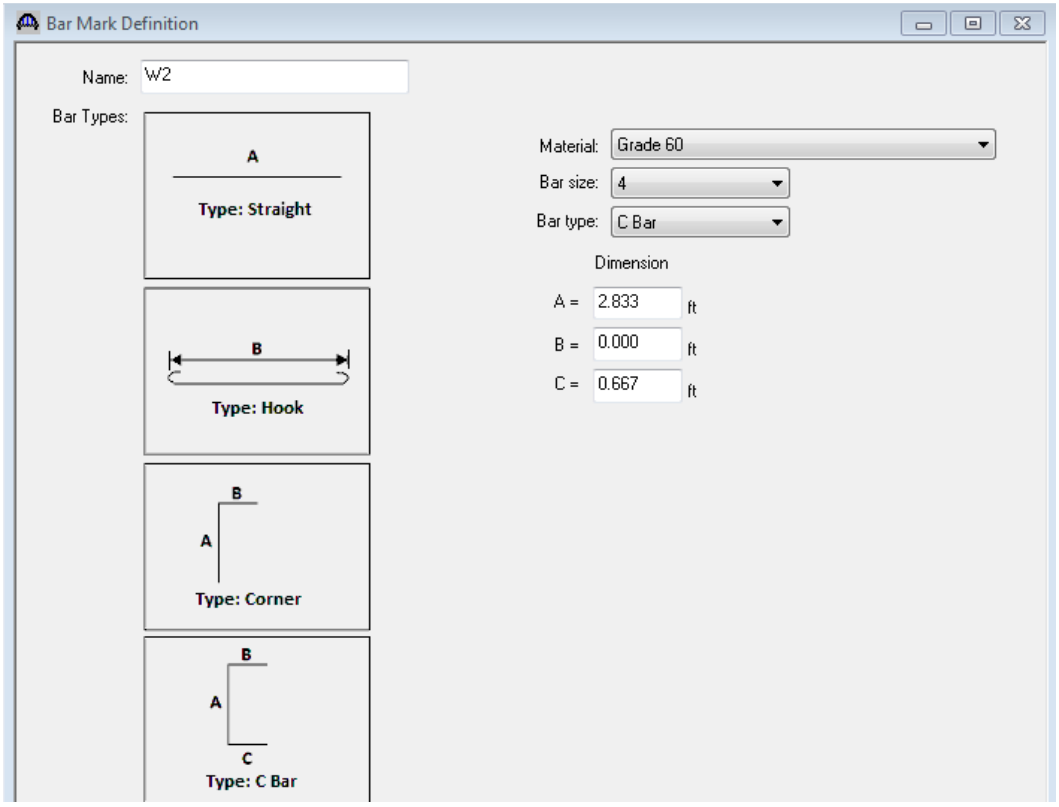
Double-click on the Bar Mark Definitions folder in the tree to create a new bar mark definition for Culvert Alt 1.

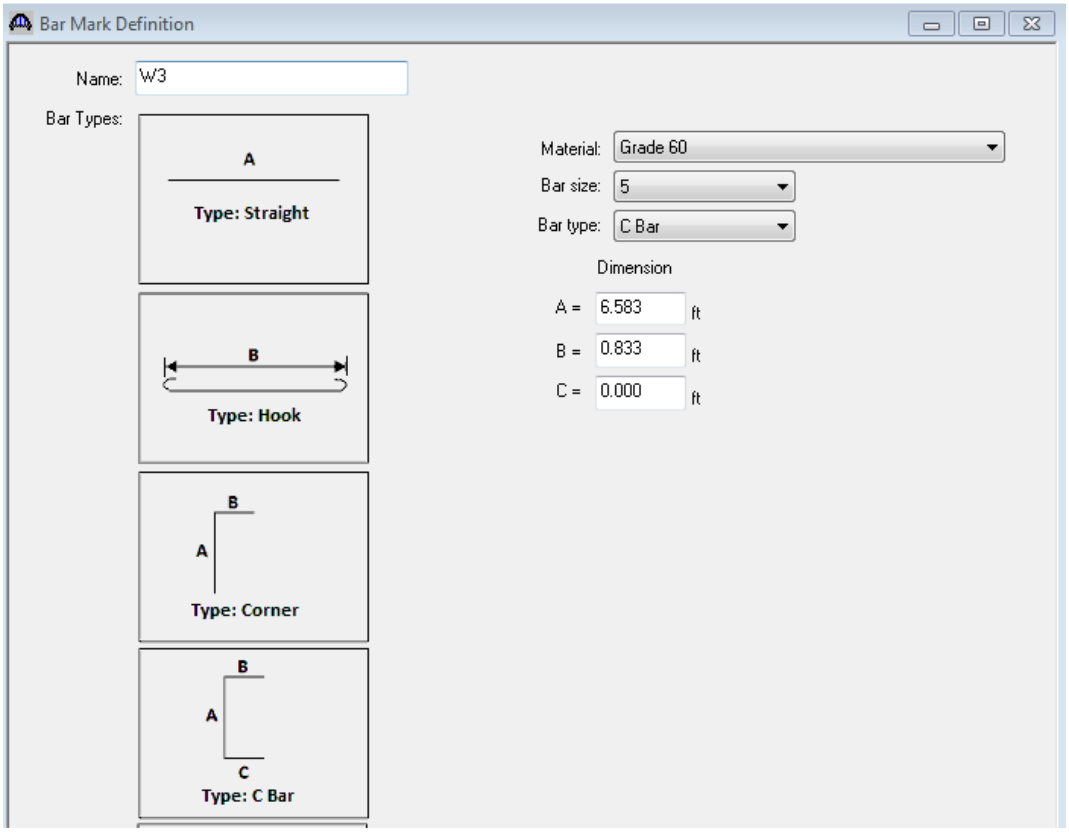
Enter the data for C1 as shown below. Click Ok to save the data to memory and close the window. Repeat the process for all bars (C2, W1, W2, W3, W4, B1, B2, T1, T2) as shown.

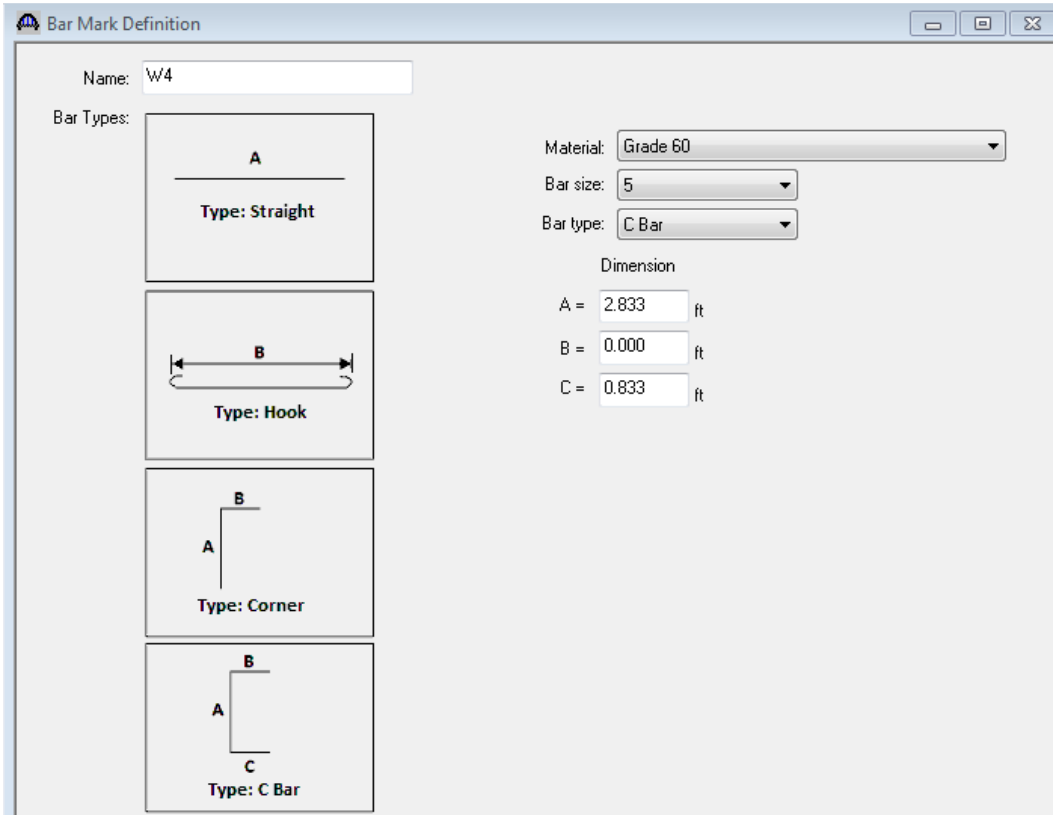


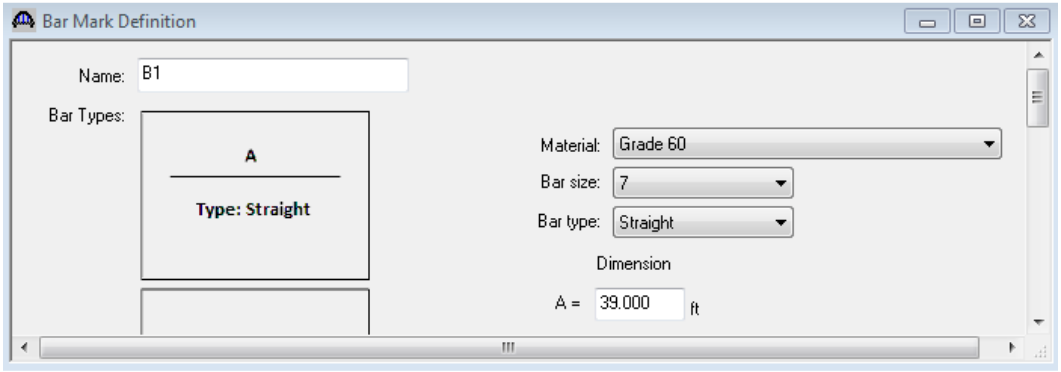

Bar Mark Definition
Name: C2
Bar Types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
Material: Grade 60
Bar size: 6
Bar type: Corner
Dimension
A = 2.833 ft
B = 3.333 ft

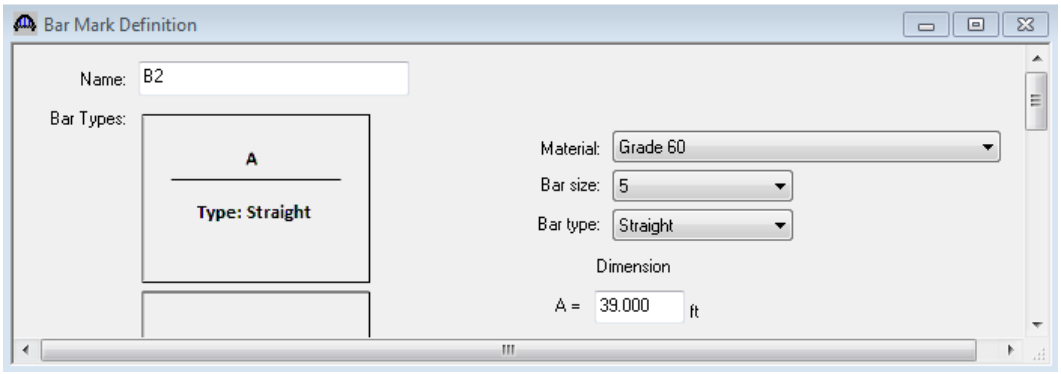

Bar Mark Definition
Name: W1
Bar Types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
B
A
C
Type: C Bar
Material: Grade 60
Bar size: 4
Bar type: C Bar
Dimension
A = 6.583 ft
B = 0.667 ft
C = 0.000 ft

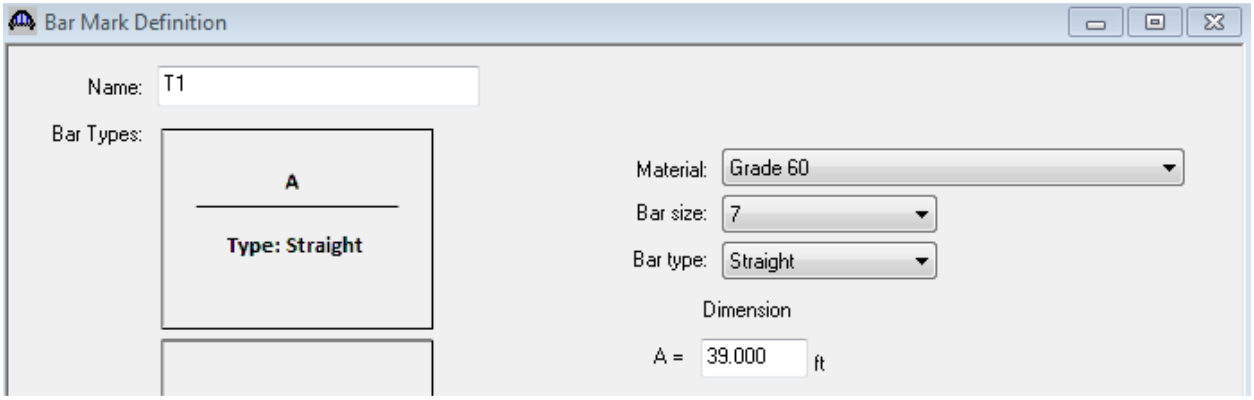

Bar Mark Definition
Name: W2
Bar Types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
B
A
C
Type: C Bar
Material: Grade 60
Bar size: 4
Bar type: C Bar
Dimension
A = 2.833 ft
B = 0.000 ft
C = 0.667 ft

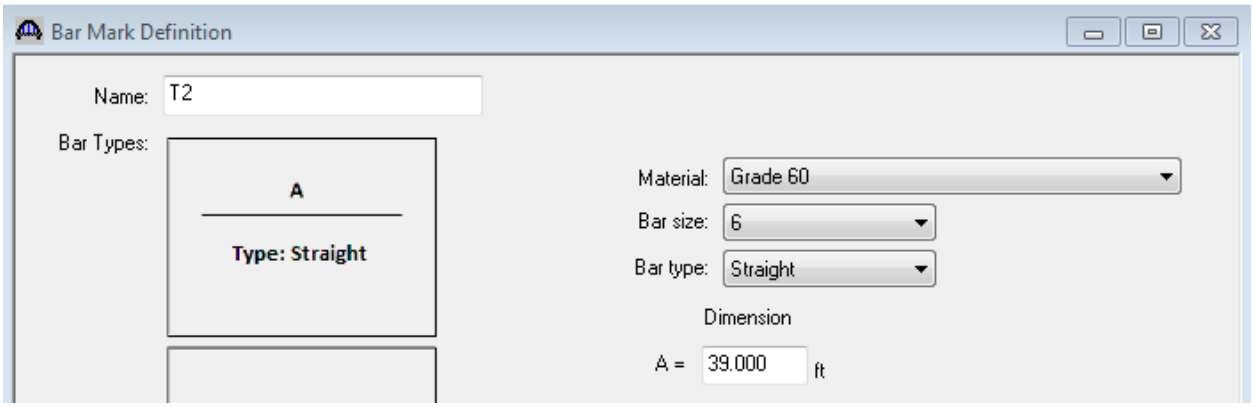

Bar Mark Definition
Name: W3
Bar Types:
A
Type: Straight
B
Type: Hook
B
A
Type: Corner
B
A
C
Type: C Bar
Material: Grade 60
Bar size: 5
Bar type: C Bar
Dimension
A = 6.583 ft
B = 0.833 ft
C = 0.000 ft


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

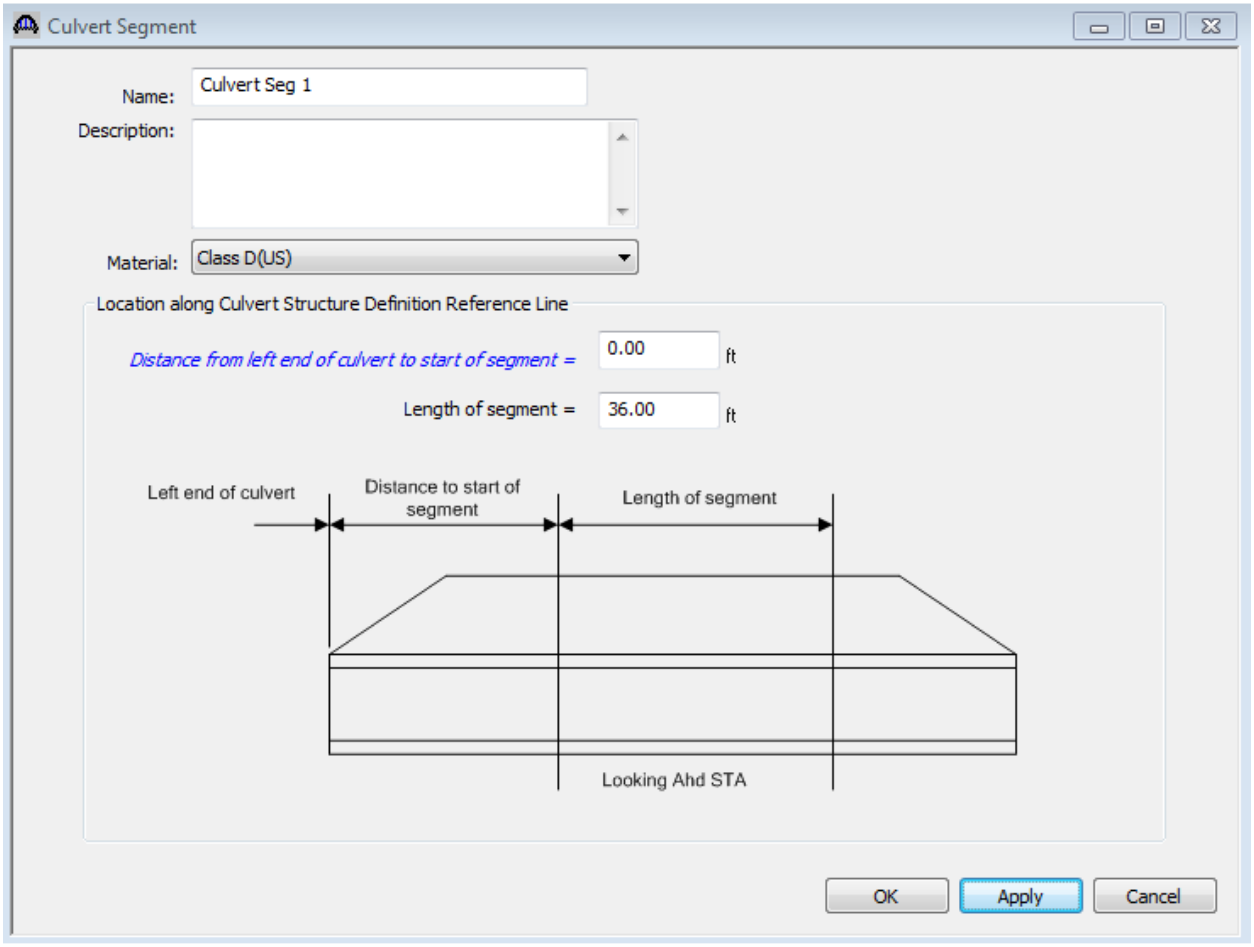

Bar Mark Definition
Name: B1
Bar Types:
A
Type: Straight
Material: Grade 60
Bar size: 7
Bar type: Straight
Dimension
A = 39.000 ft


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

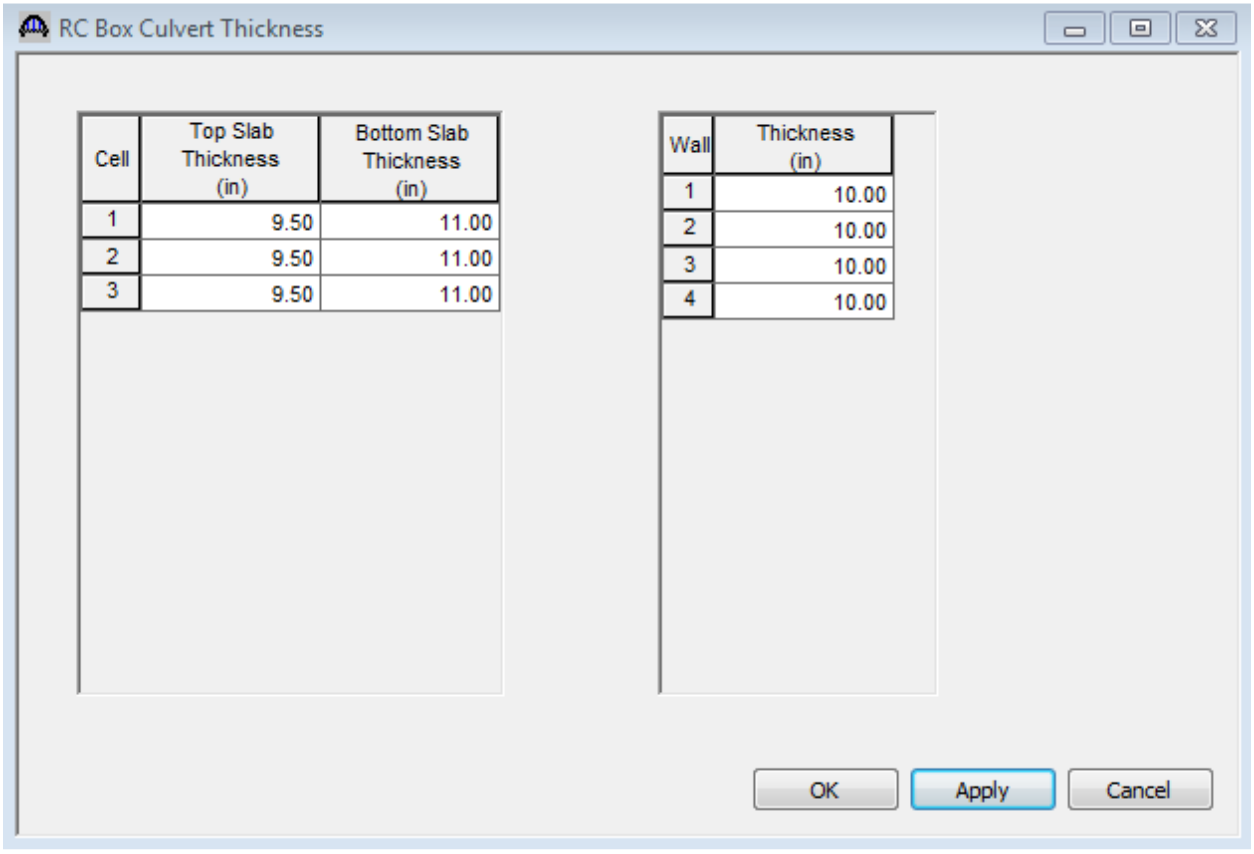

Bar Mark Definition
Name: T1
Bar Types:
A
Type: Straight
Material: Grade 60
Bar size: 7
Bar type: Straight
Dimension
A = 39.000 ft


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

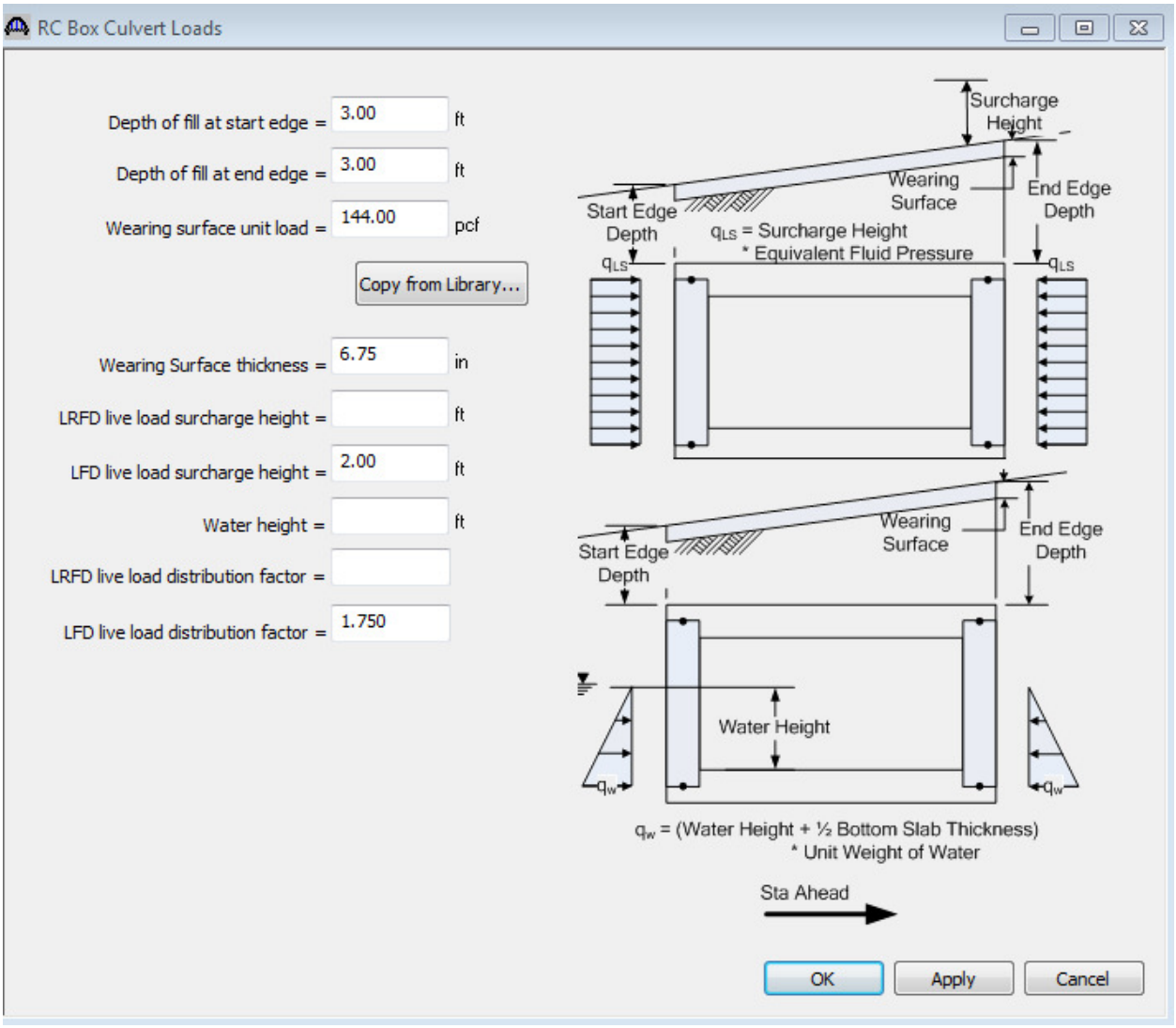
Double-click on the CULVERT SEGMENTS folder to create a new culvert segment for Culvert Alt 1. A culvert alternative may have one or more culvert segments. Enter the data as show below.



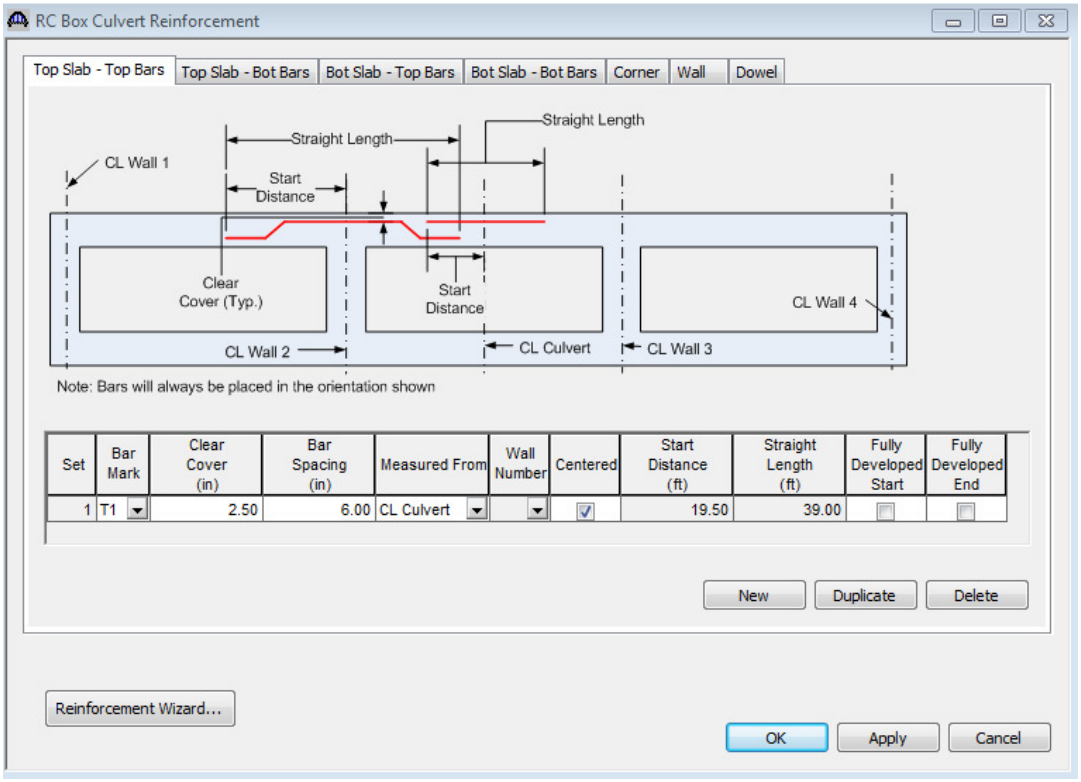
Expand the tree for Culvert Seg 1. Double-click on RC Box Culvert Thickness in the tree. Enter the slab and wall thicknesses as shown below. Click OK to save the data to memory and close the window.

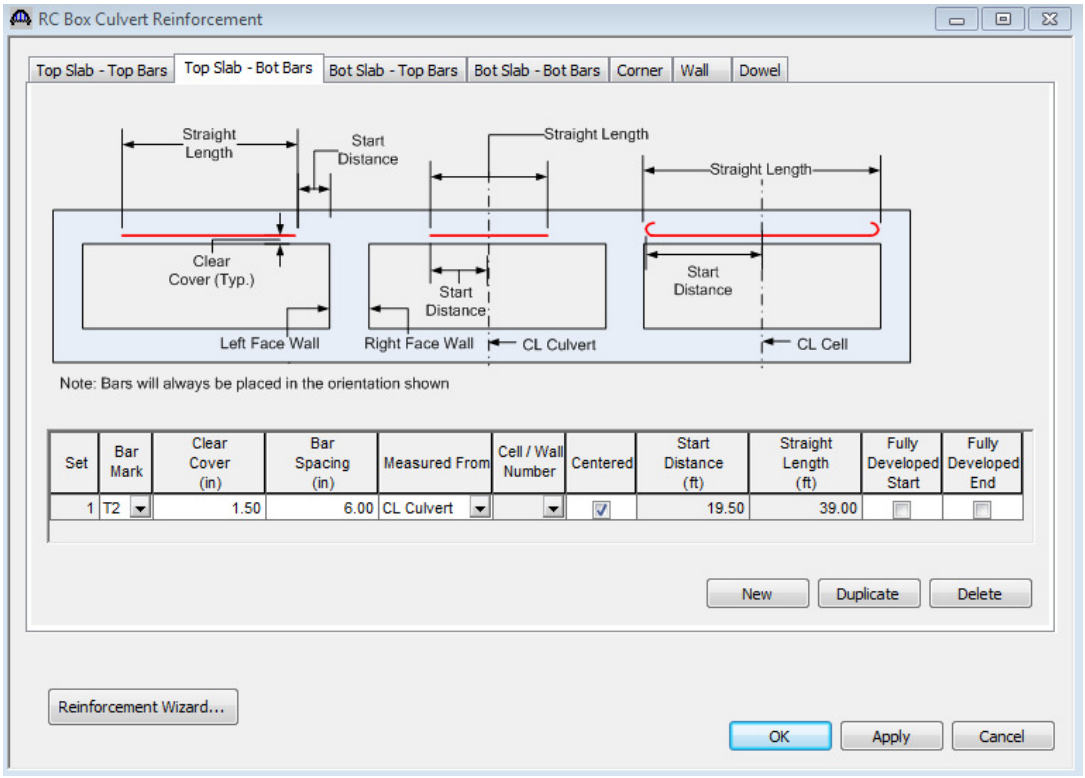


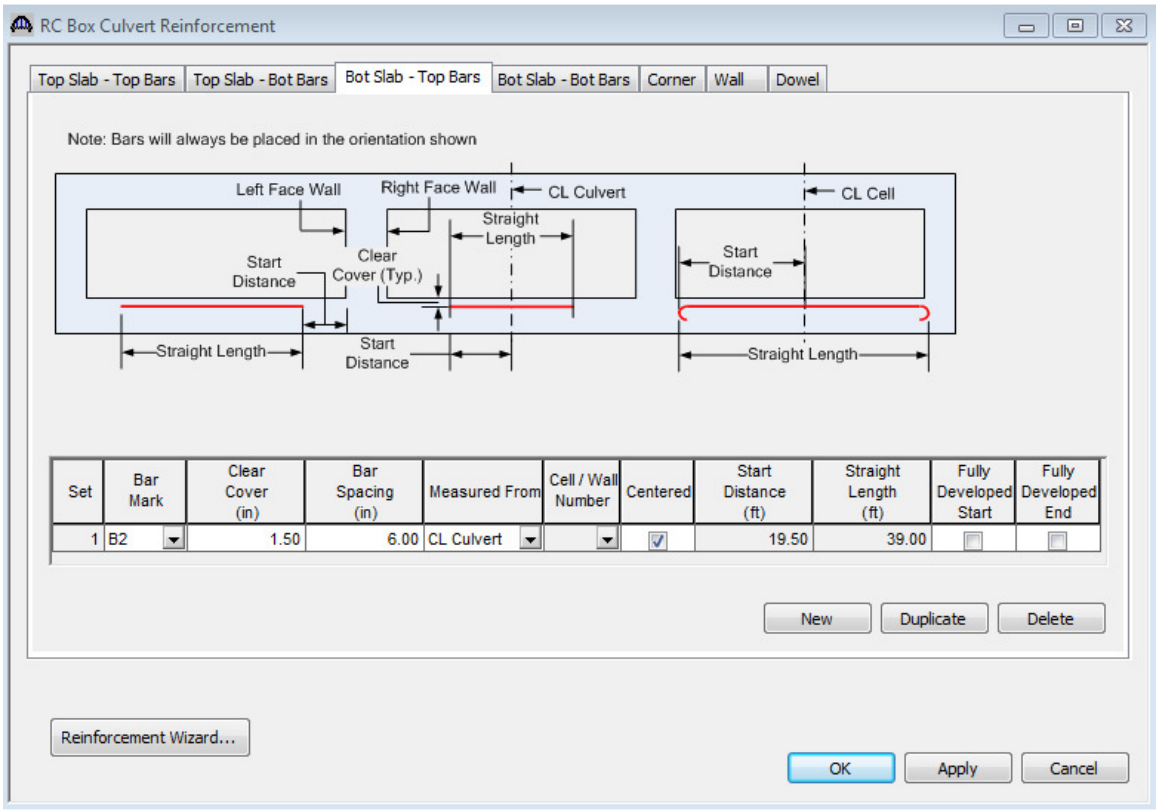
Double-click on RC Box Culvert Loads in the tree. Enter the culvert loads for Culvert Seg 1 as shown below. The wearing surface thickness includes the equivalent for the rail dead load. Click OK to save the data to memory and close the window.

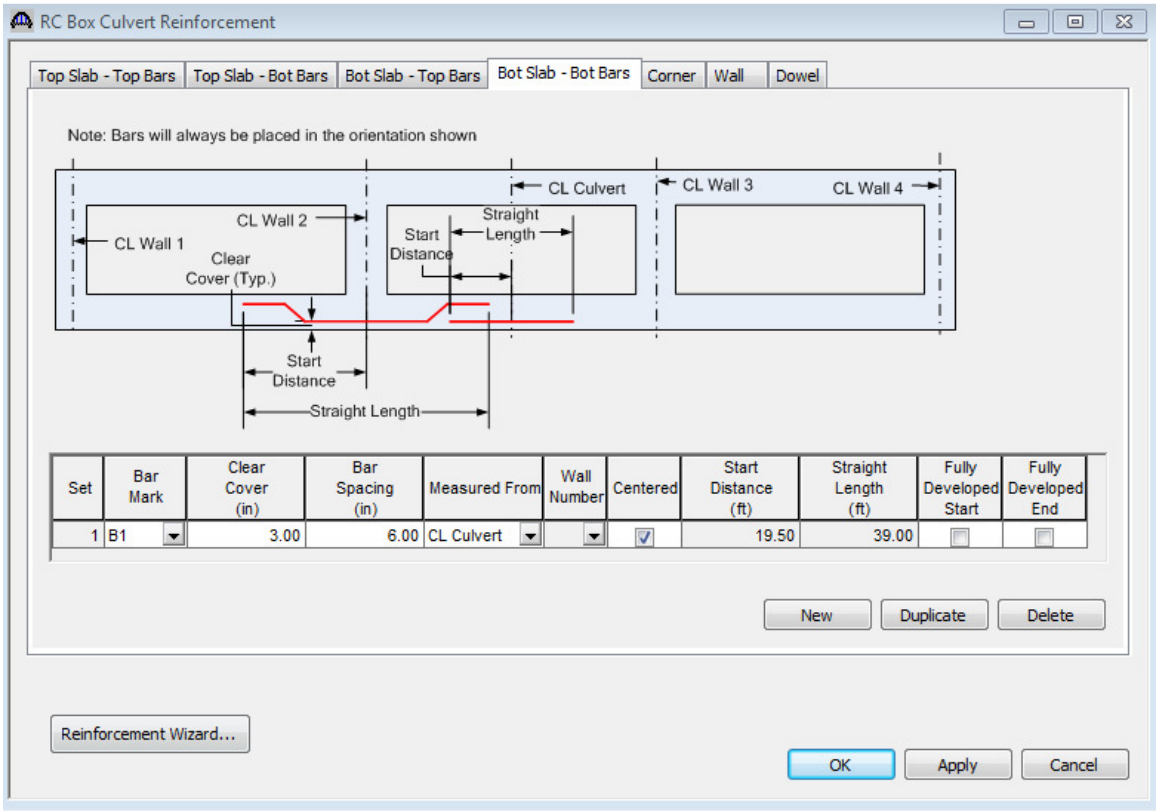


Double-click on RC Box Culvert Reinforcement in the tree. Enter the reinforcement data as shown below for each location. Click Ok to save the data to memory and close the window.



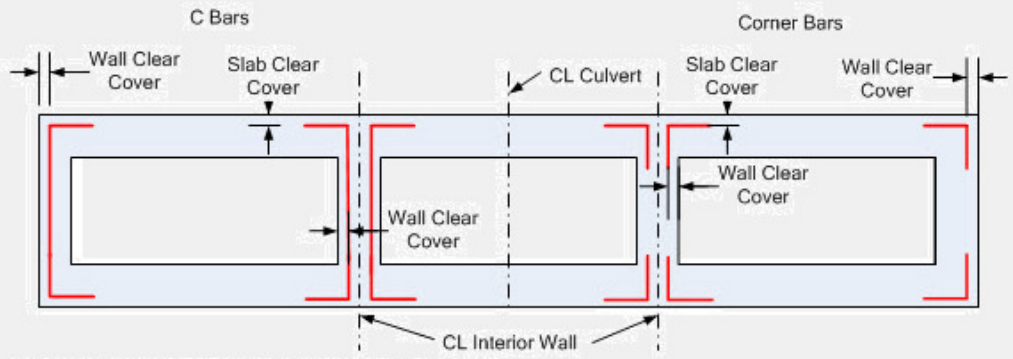



RC Box Culvert Reinforcement
Top Slab - Top Bars
Top Slab - Bot Bars
Bot Slab - Top Bars
Bot Slab - Bot Bars
Corner
Wall
Dowel
Note: Bars will always be placed in the orientation shown
Left Face Wall
Right Face Wall
CL Culvert
CL Cell
Straight Length
Start Distance
Clear Cover (Typ.)
Straight Length
Start Distance
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

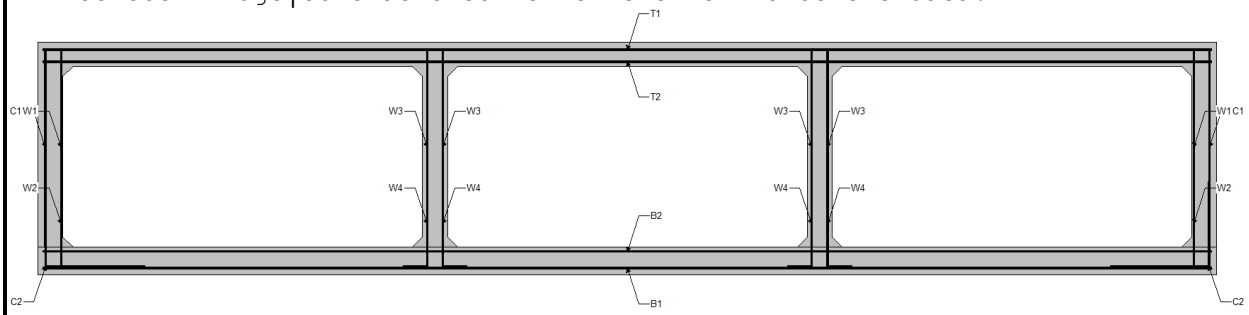
Set	Bar Mark	Wall Clear Cover (in)	Slab Clear Cover (in)	Bar Spacing (in)	Location	Wall Number	Fully Developed Vert	Fully Developed Horz
1	C2	2.00	3.00	6.00	Bottom Right	1	☐	☐
2	C2	2.00	3.00	6.00	Bottom Left	4	☐	☐
3	C1	2.00	2.50	6.00	Right	1	☐	☐
4	C1	2.00	2.50	6.00	Left	4	☐	☐
5	W1	8.50	2.50	6.00	Right	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

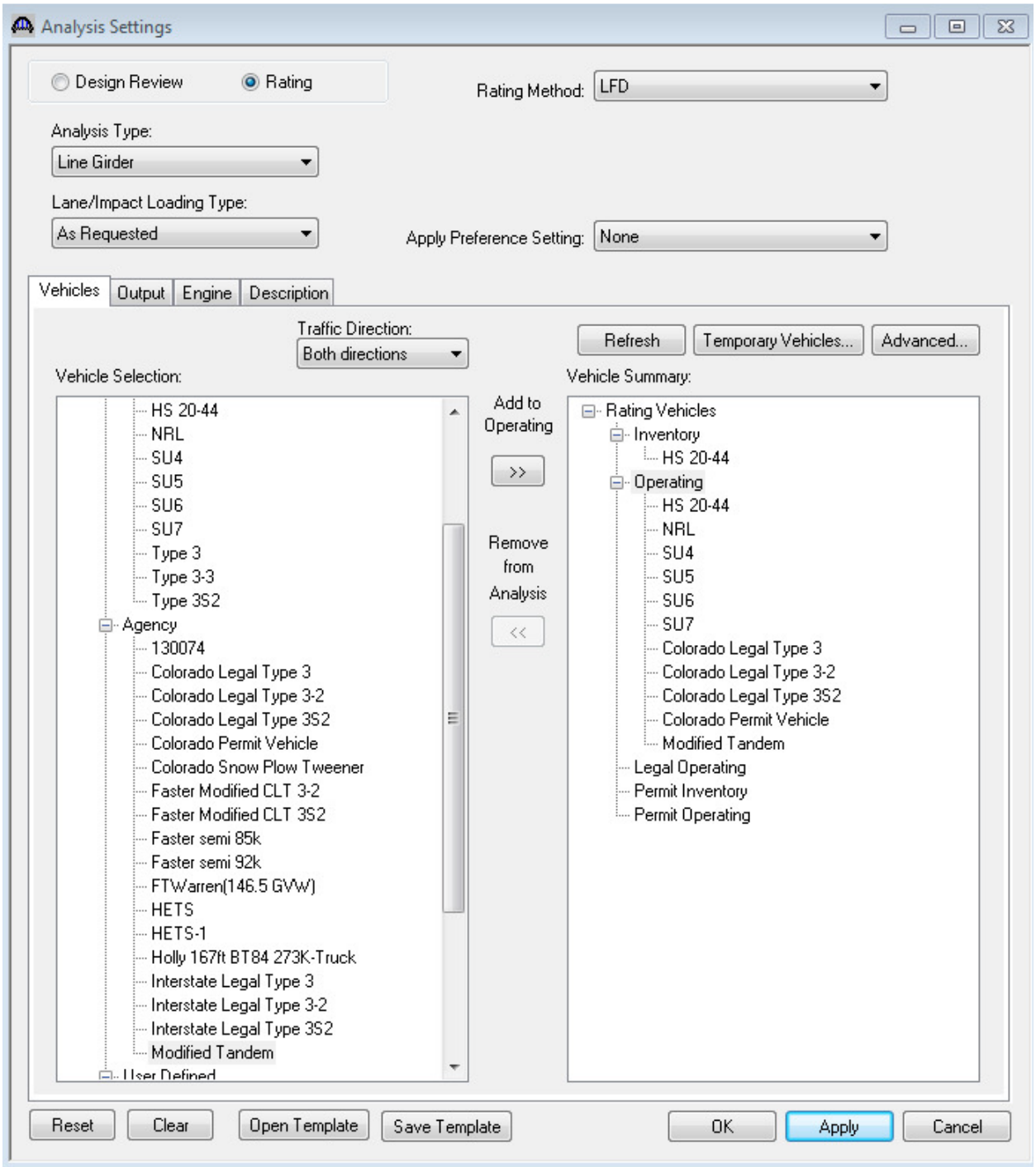
Select Bridge|Schematic to review the reinforcement data.



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

Select File|Save to save the file in BrR.

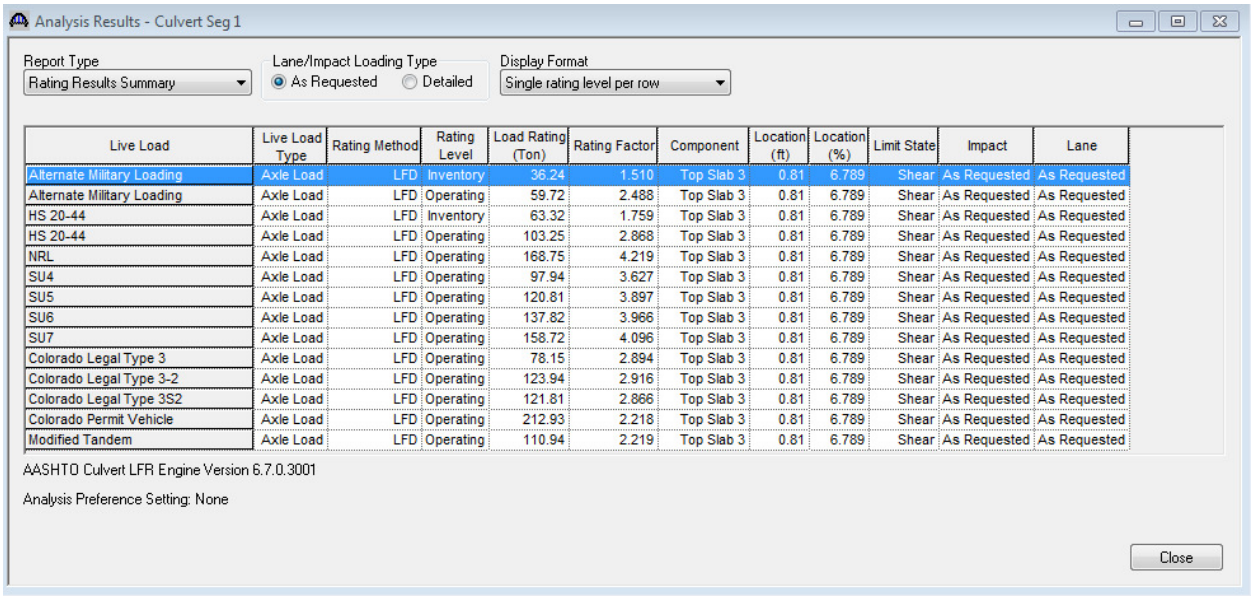
To perform LFD Design Load Rating, open the Analysis setting window by selecting Bridge|Analysis Settings. Select LFD as the Rating Method and specify the vehicles. Under Vehicles → Advanced.. select Single Lane Loaded for Colorado Permit Vehicle and Modified Tandem.



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.



Analysis Results - Culvert Seg 1

Report Type: Rating Results Summary

Lane/Impact Loading Type: (•) As Requested ( ) Detailed

Display Format: Single rating level per row

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Component	Location (ft)	Location (%)	Limit State	Impact	Lane
Alternate Military Loading	Axle Load	LFD	Inventory	36.24	1.510	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Alternate Military Loading	Axle Load	LFD	Operating	59.72	2.488	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
HS 20-44	Axle Load	LFD	Inventory	63.32	1.759	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
HS 20-44	Axle Load	LFD	Operating	103.25	2.868	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
NRL	Axle Load	LFD	Operating	168.75	4.219	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU4	Axle Load	LFD	Operating	97.94	3.627	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU5	Axle Load	LFD	Operating	120.81	3.897	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU6	Axle Load	LFD	Operating	137.82	3.966	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
SU7	Axle Load	LFD	Operating	158.72	4.096	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Legal Type 3	Axle Load	LFD	Operating	78.15	2.894	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Legal Type 3-2	Axle Load	LFD	Operating	123.94	2.916	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Legal Type 3S2	Axle Load	LFD	Operating	121.81	2.866	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Colorado Permit Vehicle	Axle Load	LFD	Operating	212.93	2.218	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested
Modified Tandem	Axle Load	LFD	Operating	110.94	2.219	Top Slab 3	0.81	6.789	Shear	As Requested	As Requested

AASHTO Culvert LFR Engine Version 6.7.0.3001

Analysis Preference Setting: None

Close

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.

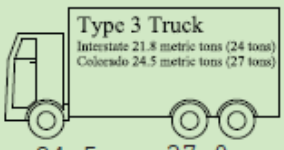
COLORADO DEPARTMENT OF TRANSPORTATION

LOAD FACTOR RATING SUMMARY

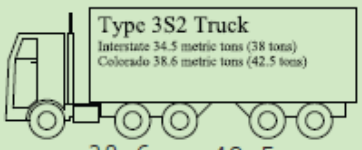
Rated using:
Asphalt thickness: 914 mm (36 in.)
☑ Colorado legal loads
☐ Interstate legal loads

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

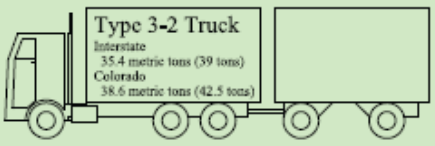
Structural Member	3-CELL CBC			
	Metric Tons (Tons)			
Inventory Alt. Military	32.9 (36.2)	( )	( )	( )
Operating Alt. Military	54.2 (59.7)	( )	( )	( )
Type 3 truck	70.9 (78.2)	( )	( )	( )
Type 3S2 truck	110.5 (121.8)	( )	( )	( )
Type 3-2 truck	112.4 (123.9)	( )	( )	( )
Type SU4 truck (27T)	( )	( )	( )	( )
Type SU5 truck (31T)	( )	( )	( )	( )
Type SU6 truck (35T)	( )	( )	( )	( )
Type SU7 truck (39T)	( )	( )	( )	( )
NRL (40T)	153.1 (168.8)	( )	( )	( )
Permit Truck Single Lane D.F.	193.1 (212.9)	( )	( )	( )



24.5 Metric tons (27.0 tons)



38.6 Metric tons (42.5 tons)



38.6 Metric tons (42.5 tons)

Comments: (T = tons)
Modified Tandem 100.6 (110.9)

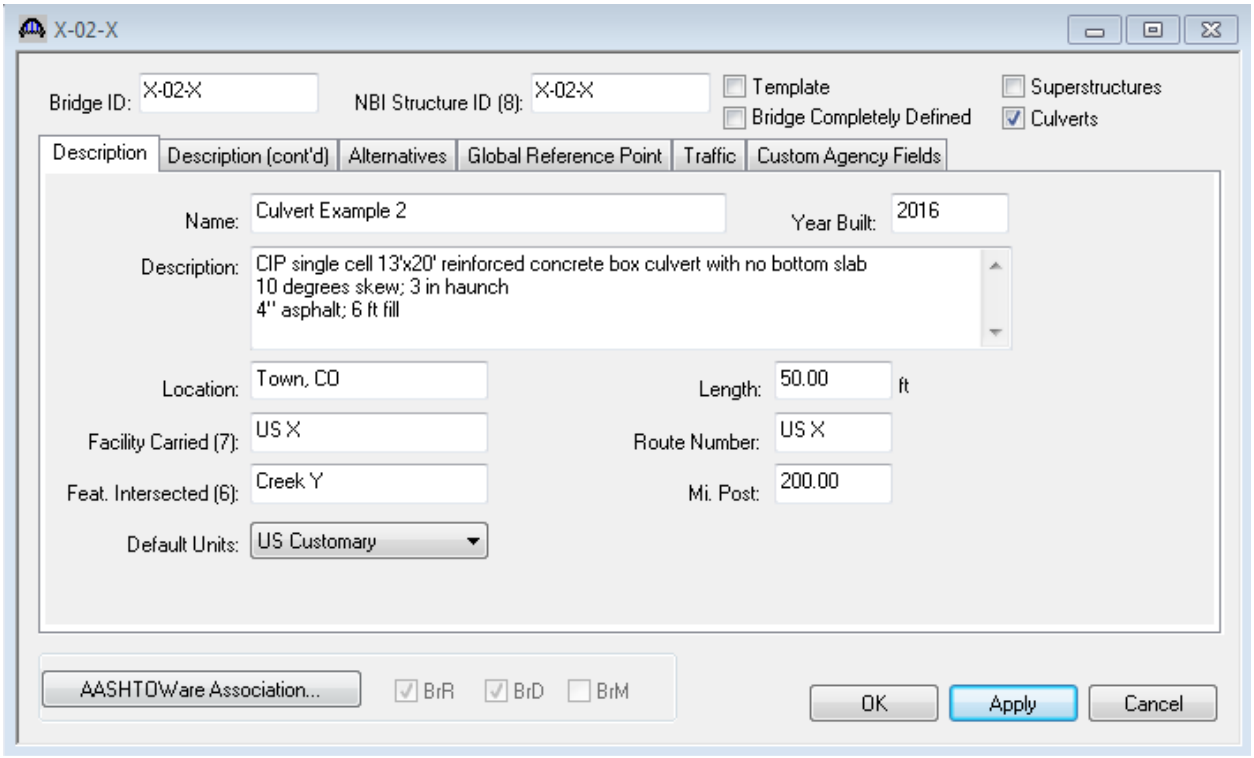
Total structure length (face to face of end walls) = 36'-0"; Fill height 3'-0"; Asphalt 3 in
NBI Item 62 condition state level = 8; Plans available = Yes
Load induced damage present = No; Pending essential repairs = No
Color Code: White
Rated with BrR 6.7.0.3001 AASHTO Culvert Engine

Rated by:	Date:	Checked by:	Date:

Previous editions are obsolete and may not be used — CDOT Staff Bridge - LFR 10/2014

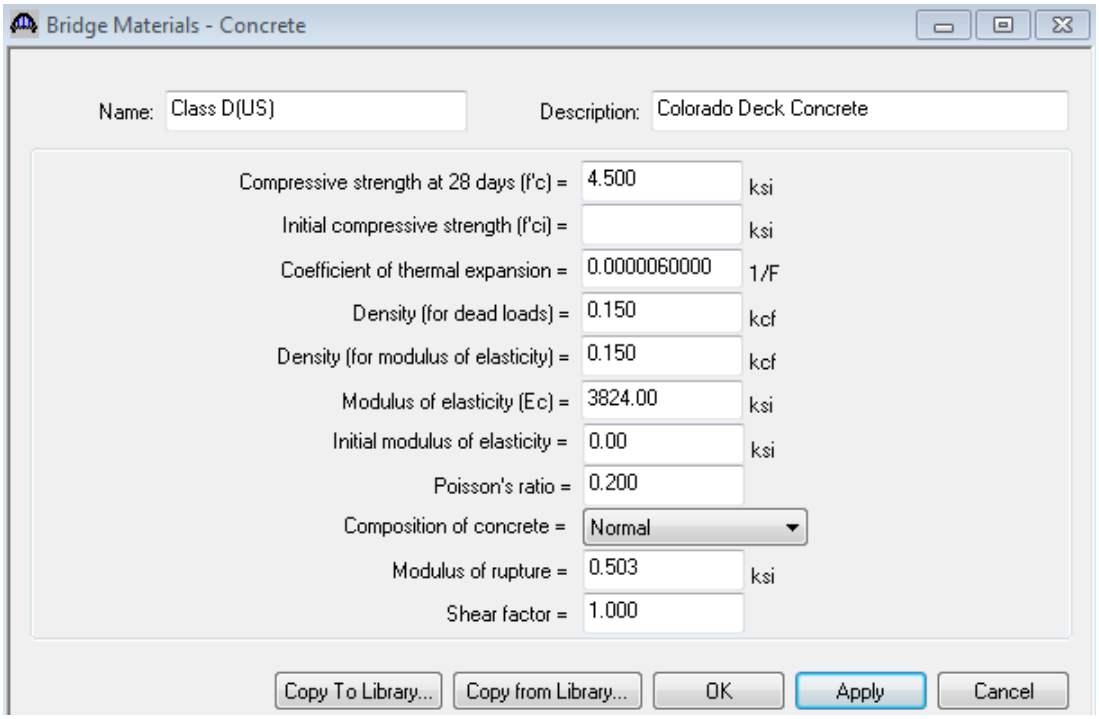
II. **AASHTOWare** BrR Program, Example 2 (LRFR) – Structure No. X-02-X

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



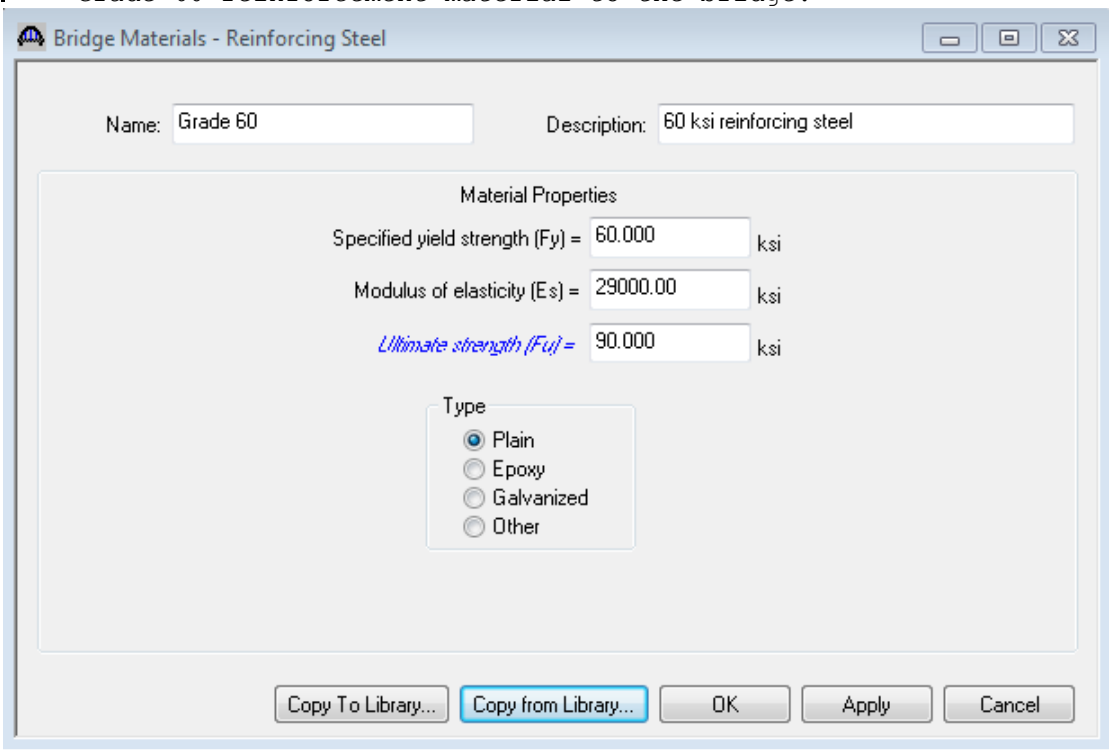
Close the window by clicking OK. This saves the data to memory and closes the window.

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.

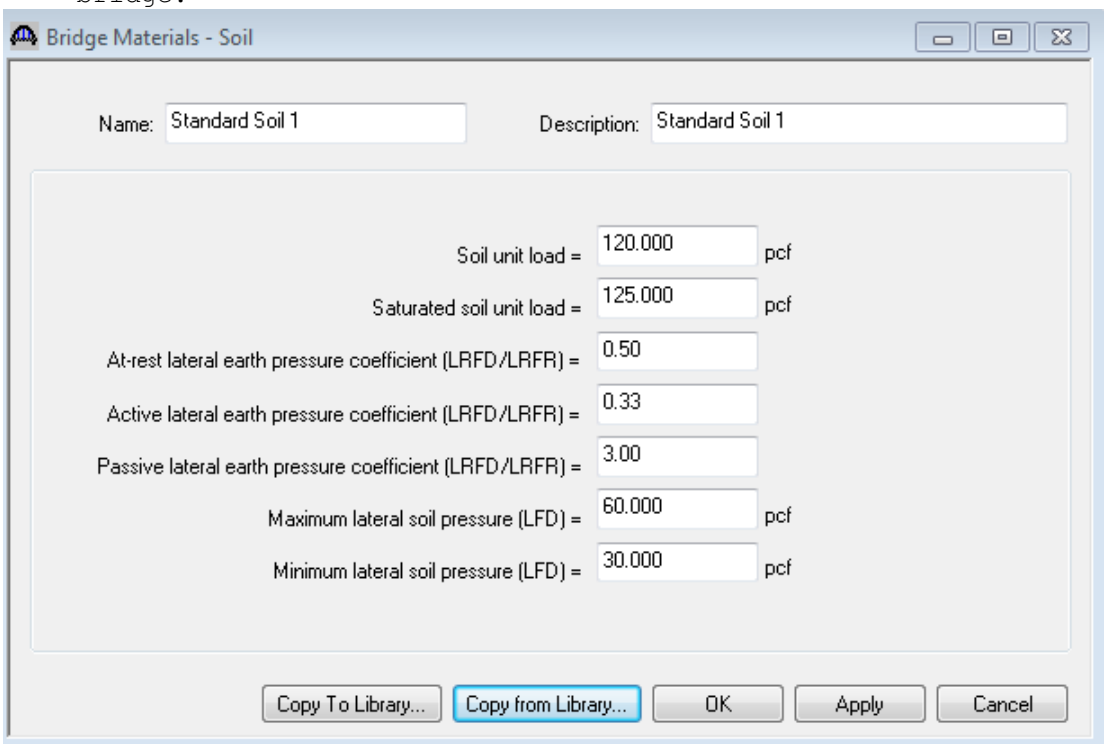


When plans are available, use the minimum concrete strength and yield strength values given in the plans. If plan values are not known, values given in Section 1 of the Bridge Rating Manual for the applicable year of construction may be followed.

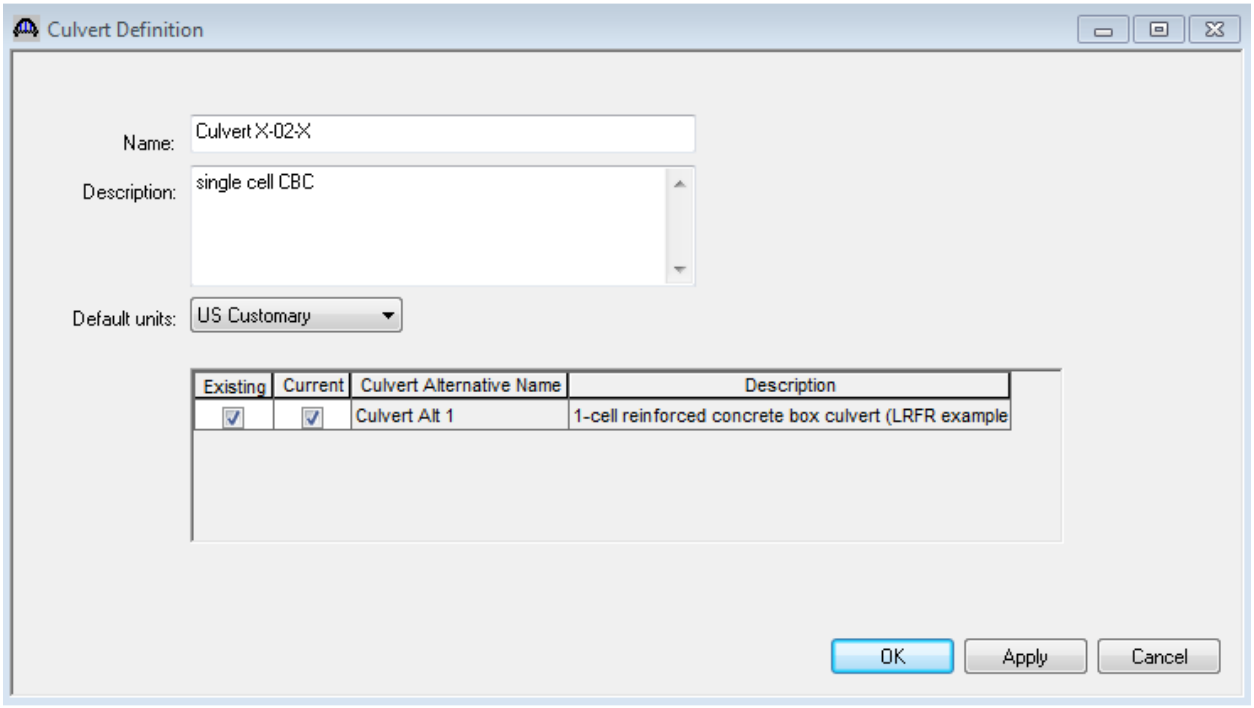
Double-click on the Reinforcing Steel folder to create a new reinforcement material. Click on the Copy from Library button to copy the Grade 60 reinforcement material to the bridge.



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.

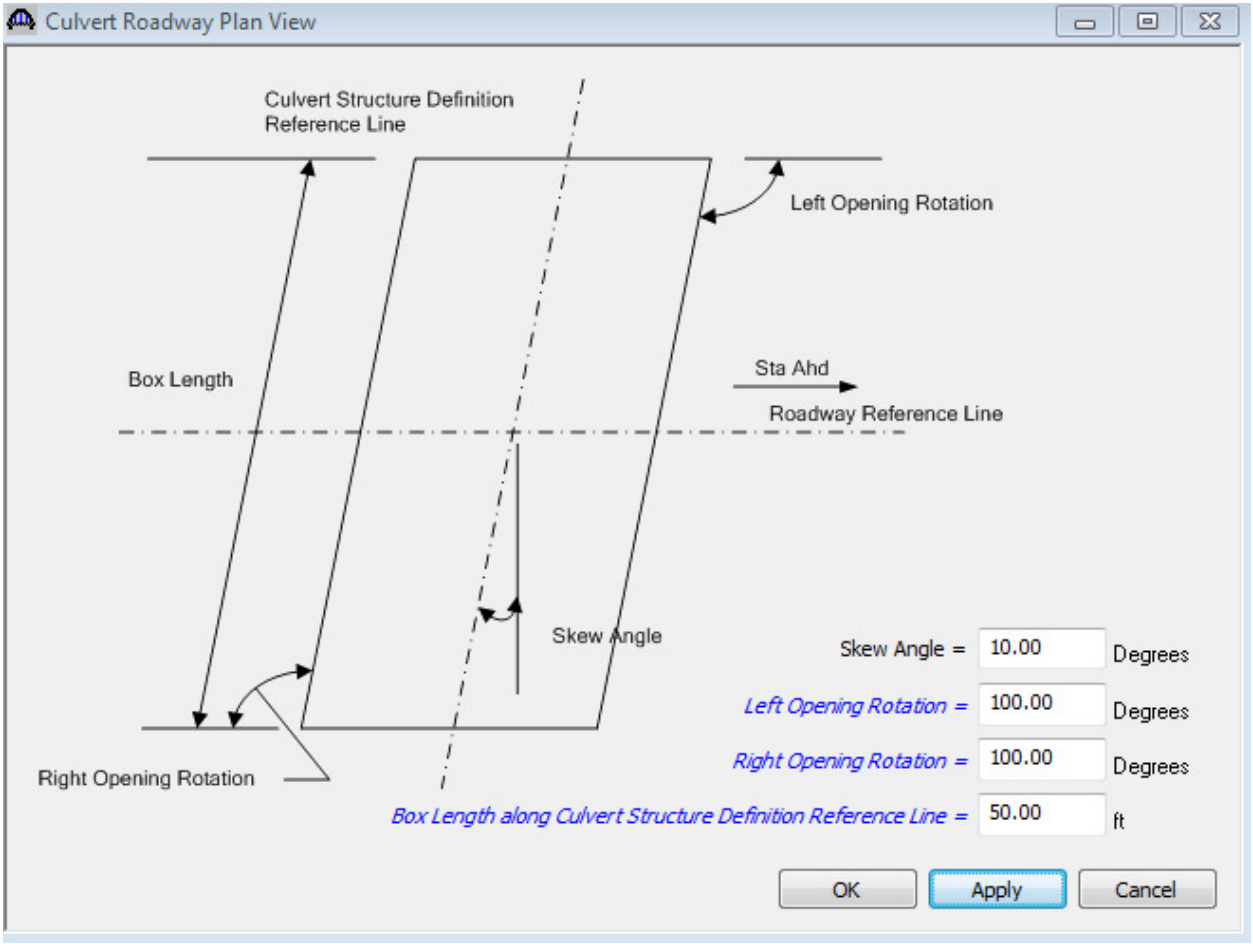


Double-click on the CULVERT DEFINITIONS folder to create a new culvert definition. Enter the Culvert Definition name as show below. The first Culvert Alternative that we create will automatically be assigned as the Existing and Current Culvert Alternative for this Culvert Definition.

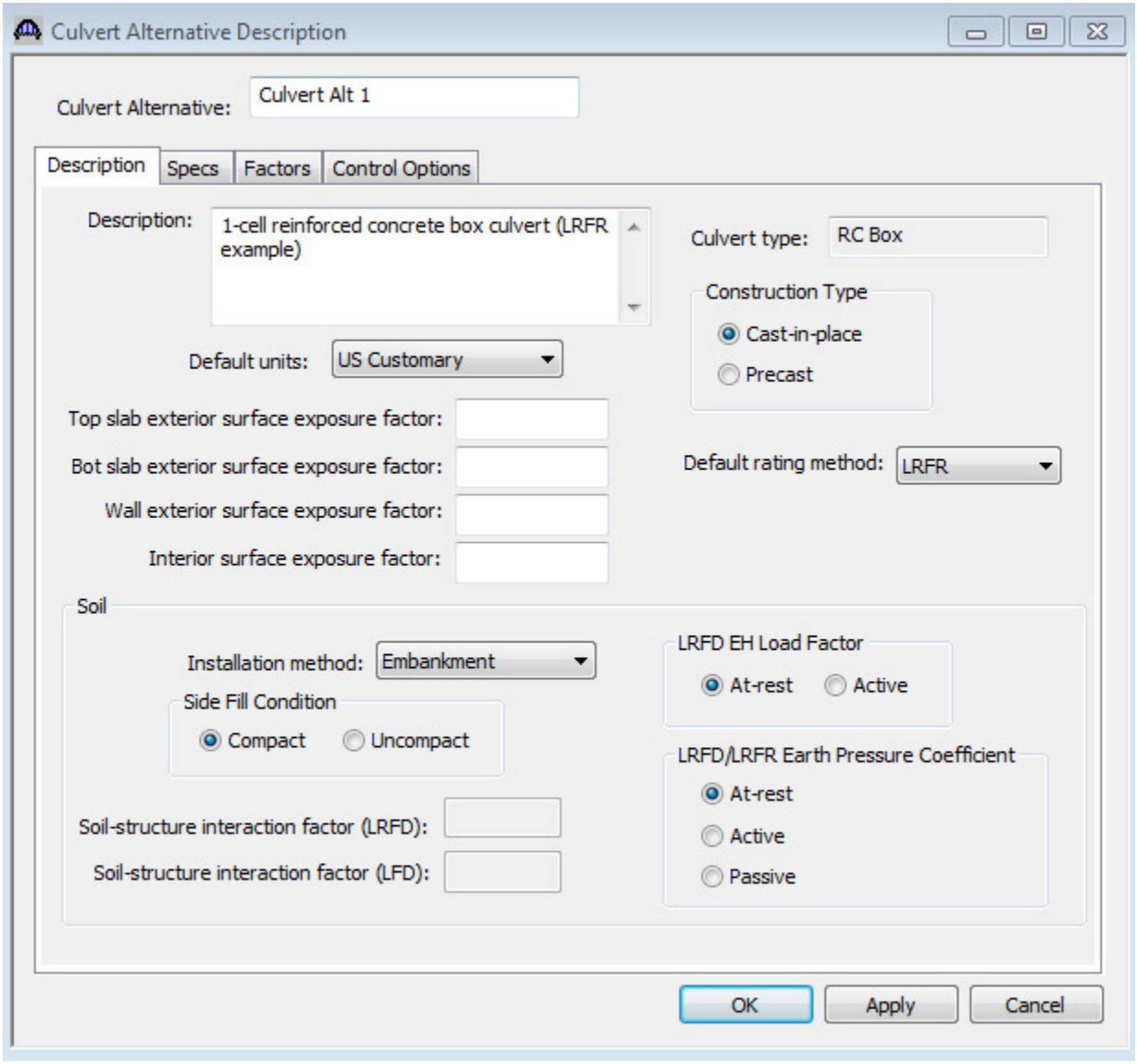


Expand the tree for Culvert Definition X-02-X.

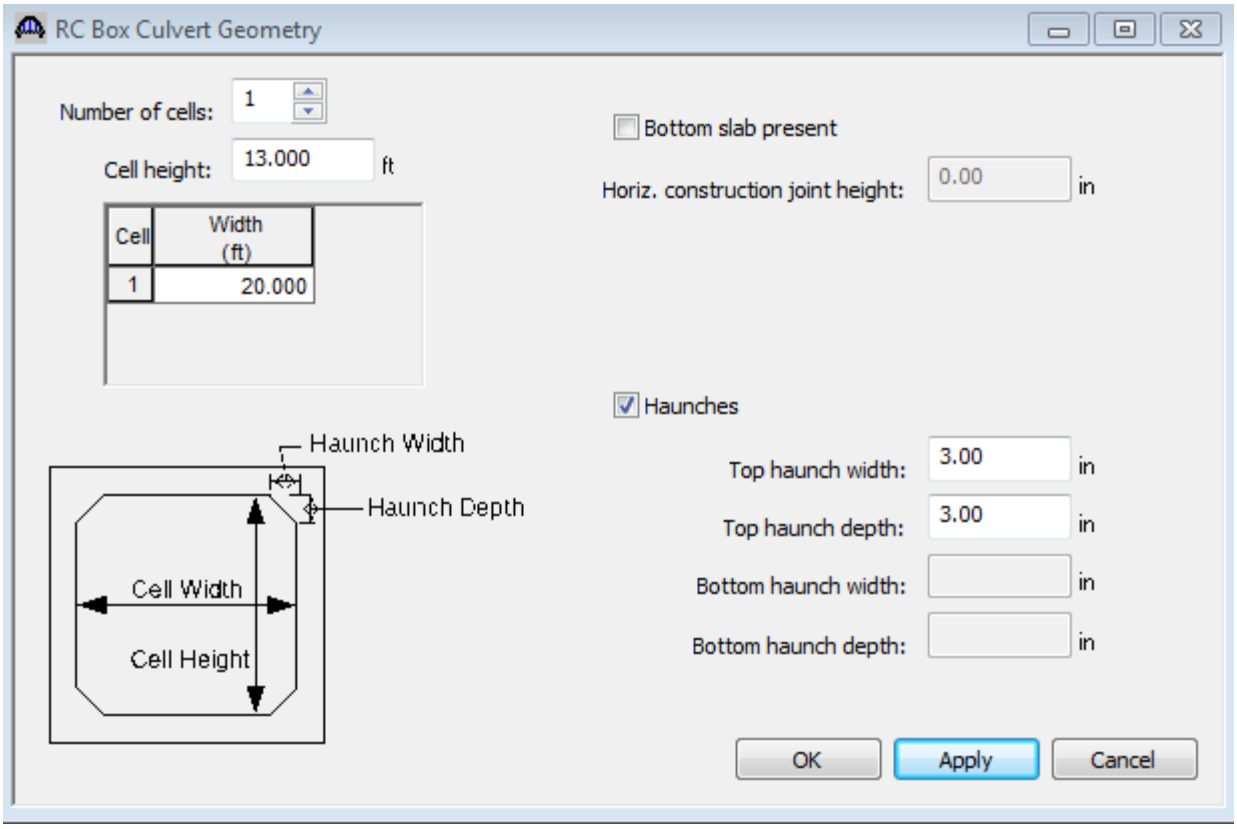
Double-click on the Roadway Plan View to enter the skew angles as shown below.



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

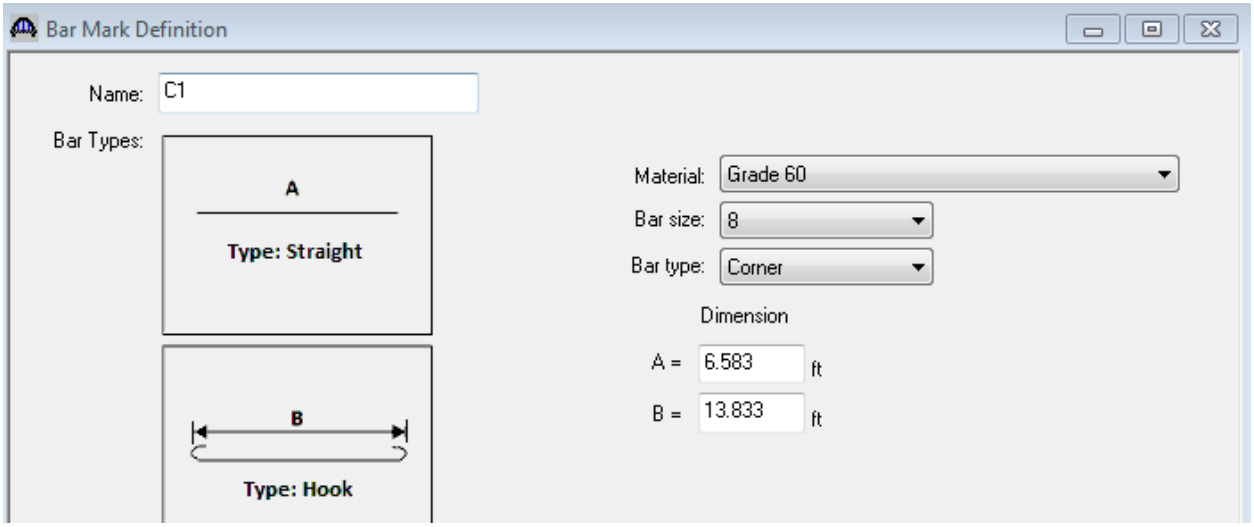


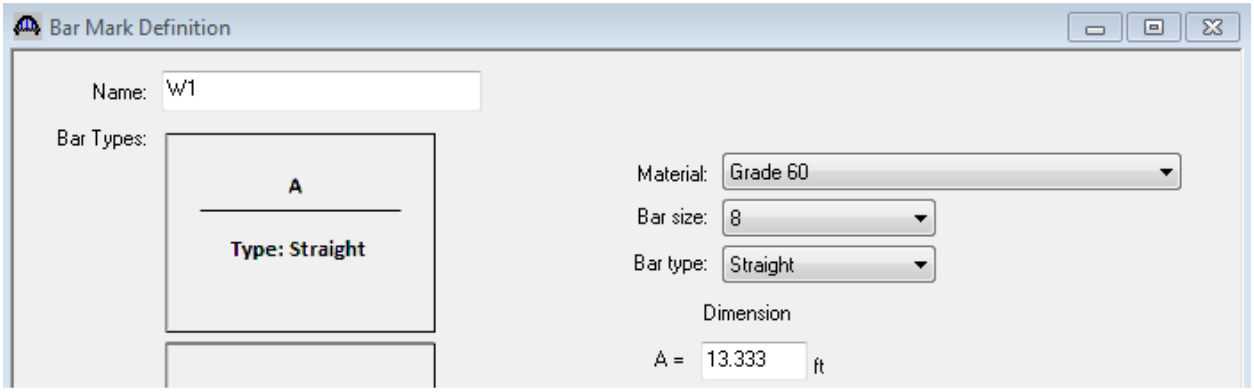
Expand the tree for Culvert Alt 1.
Double-click on RC Box Culvert Geometry in the tree. Enter the data as shown below. Click Ok to save the data to memory and close the window.

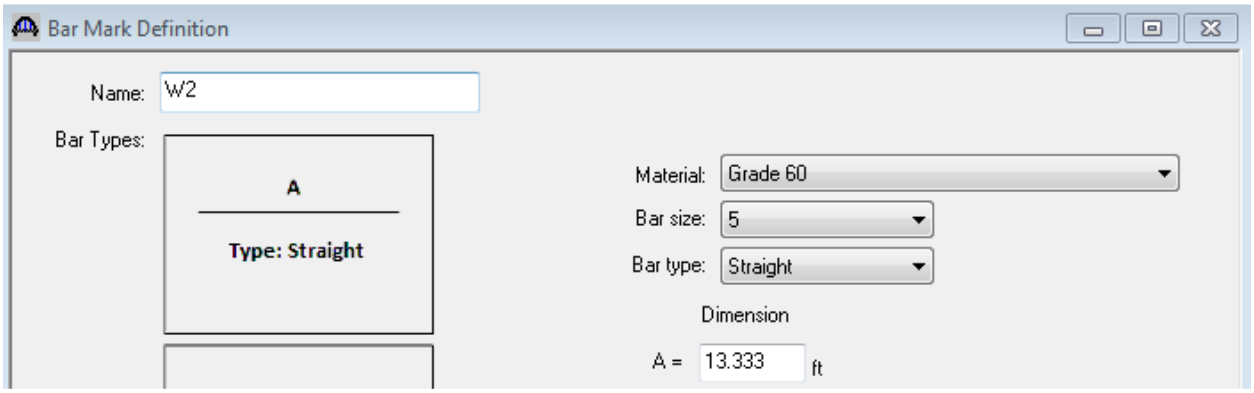


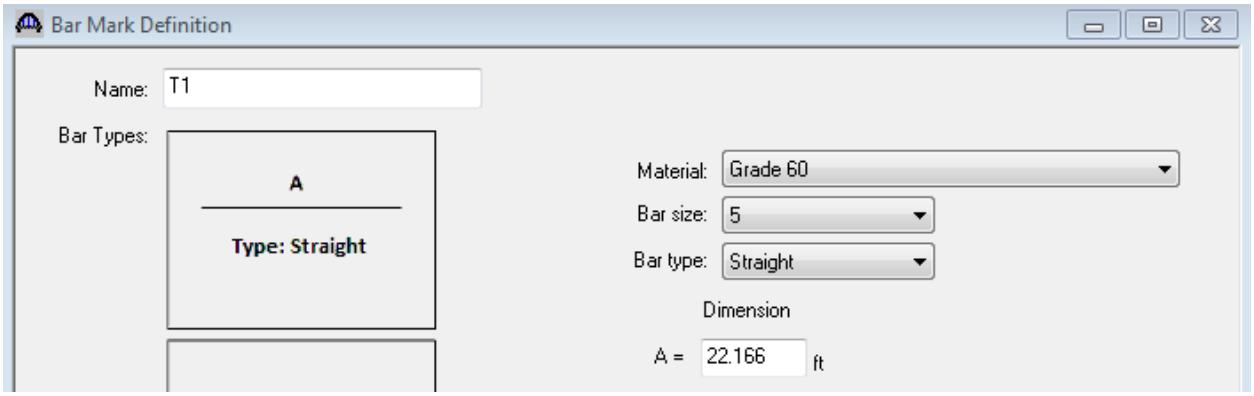
Double-click on the Bar Mark Definitions folder in the tree to create a new bar mark definition for Culvert Alt 1.

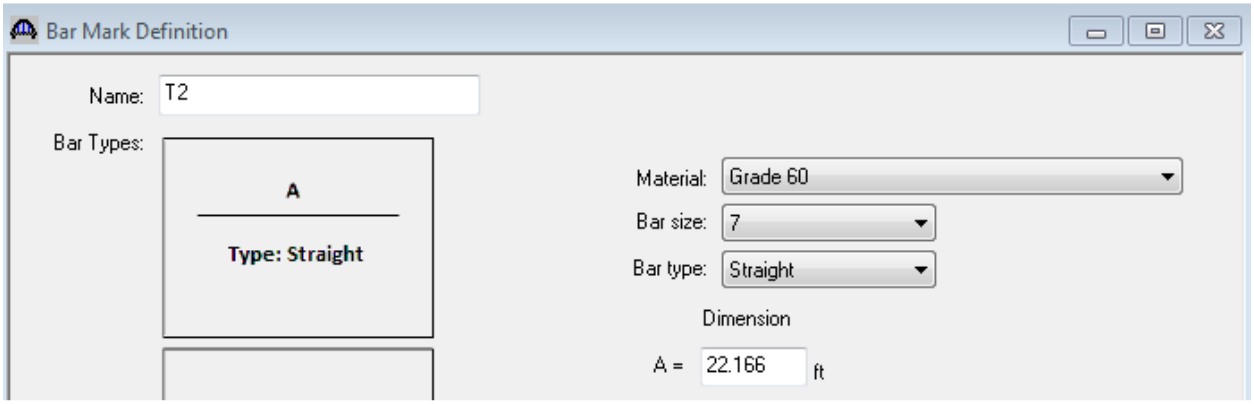
Enter the data for C1 as shown below. Click Ok to save the data to memory and close the window. Repeat the process for all bars (W1, W2, T1, T2) as shown.



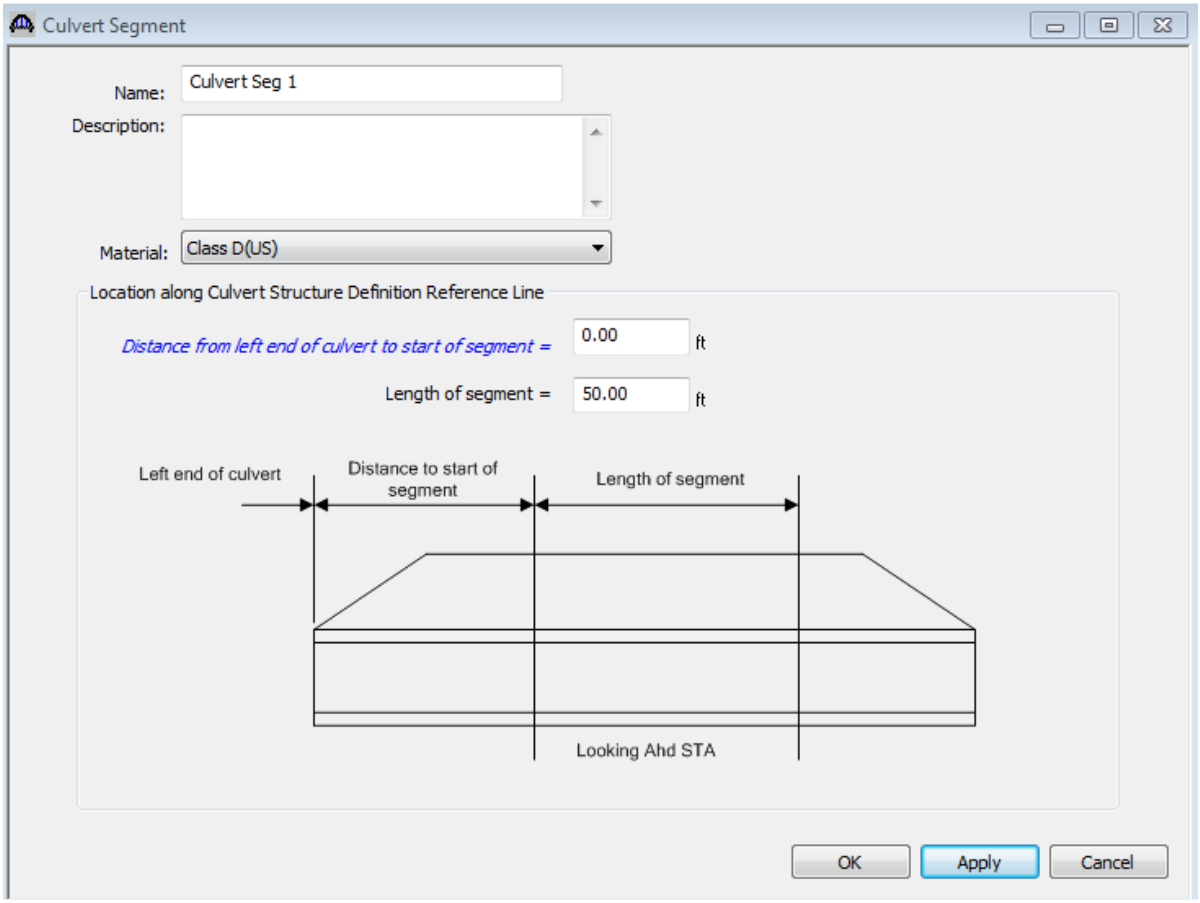




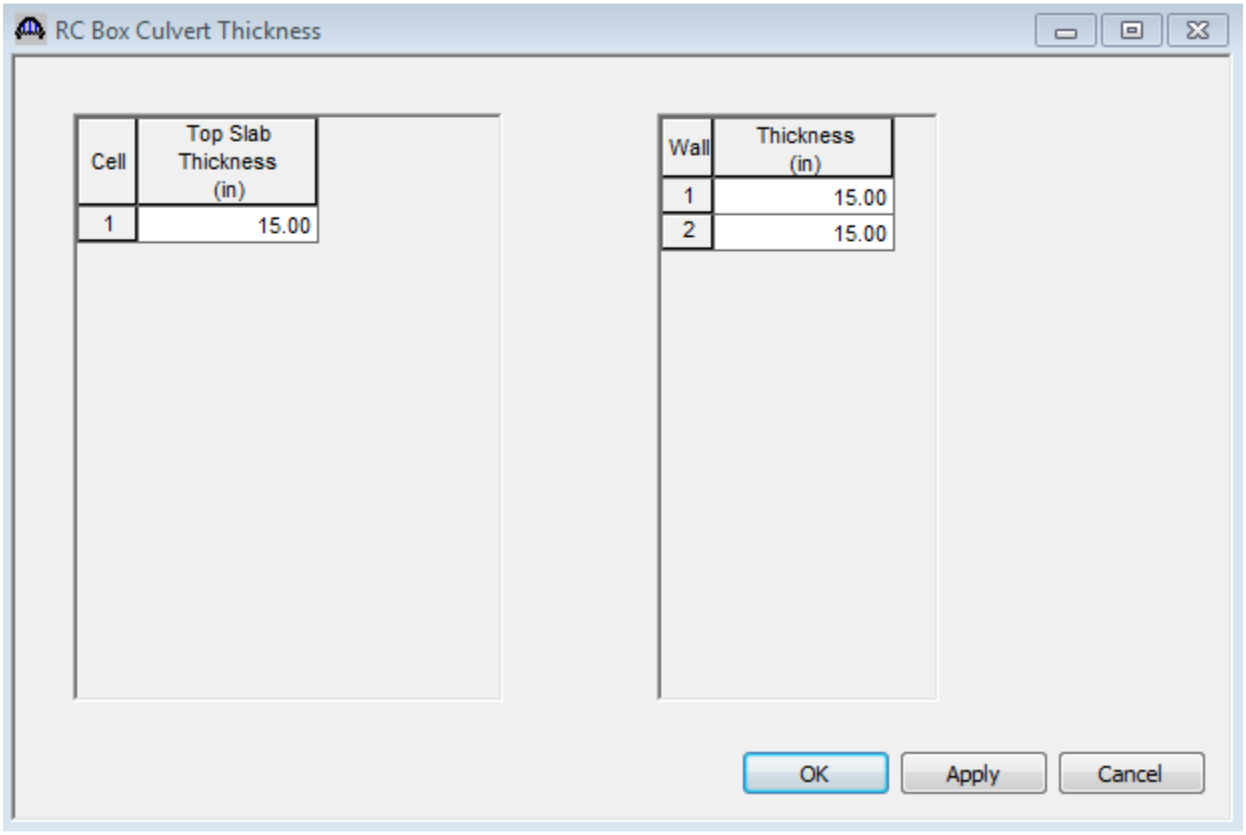

Bar Mark Definition
Name: T1
Bar Types:
A
Type: Straight
Material: Grade 60
Bar size: 5
Bar type: Straight
Dimension
A = 22.166 ft


Bar Mark Definition
Name: T2
Bar Types:
A
Type: Straight
Material: Grade 60
Bar size: 7
Bar type: Straight
Dimension
A = 22.166 ft

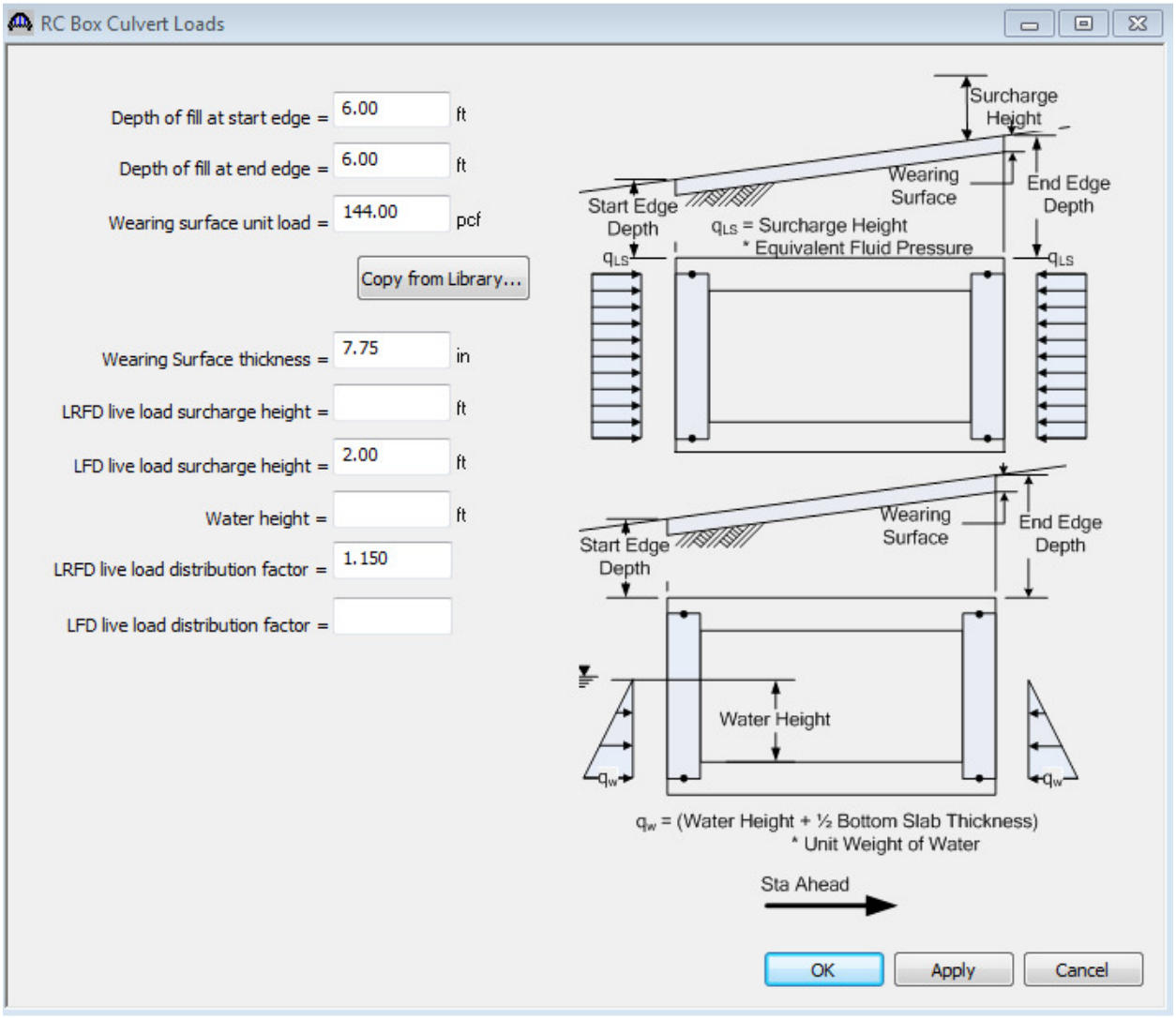
Double-click on the CULVERT SEGMENTS folder to create a new culvert segment for Culvert Alt 1. A culvert alternative may have one or more culvert segments. Enter the data as show below.



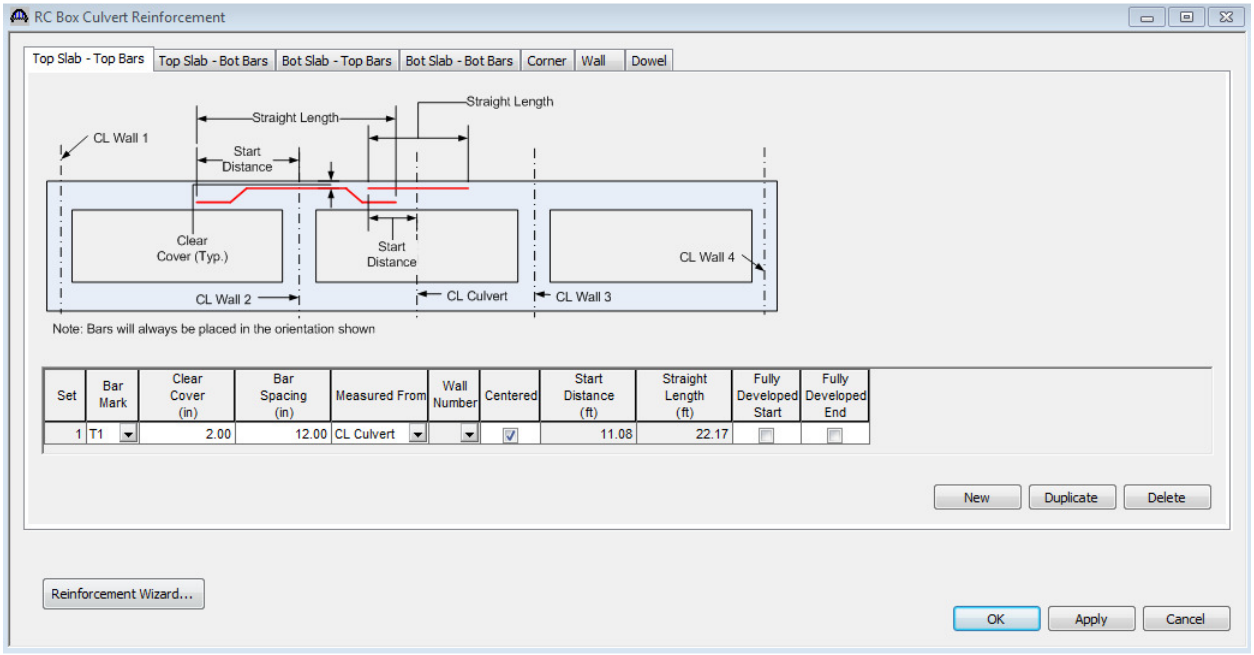
Expand the tree for Culvert Seg 1. Double-click on RC Box Culvert Thickness in the tree. Enter the slab and wall thicknesses as shown below. Click OK to save the data to memory and close the window.

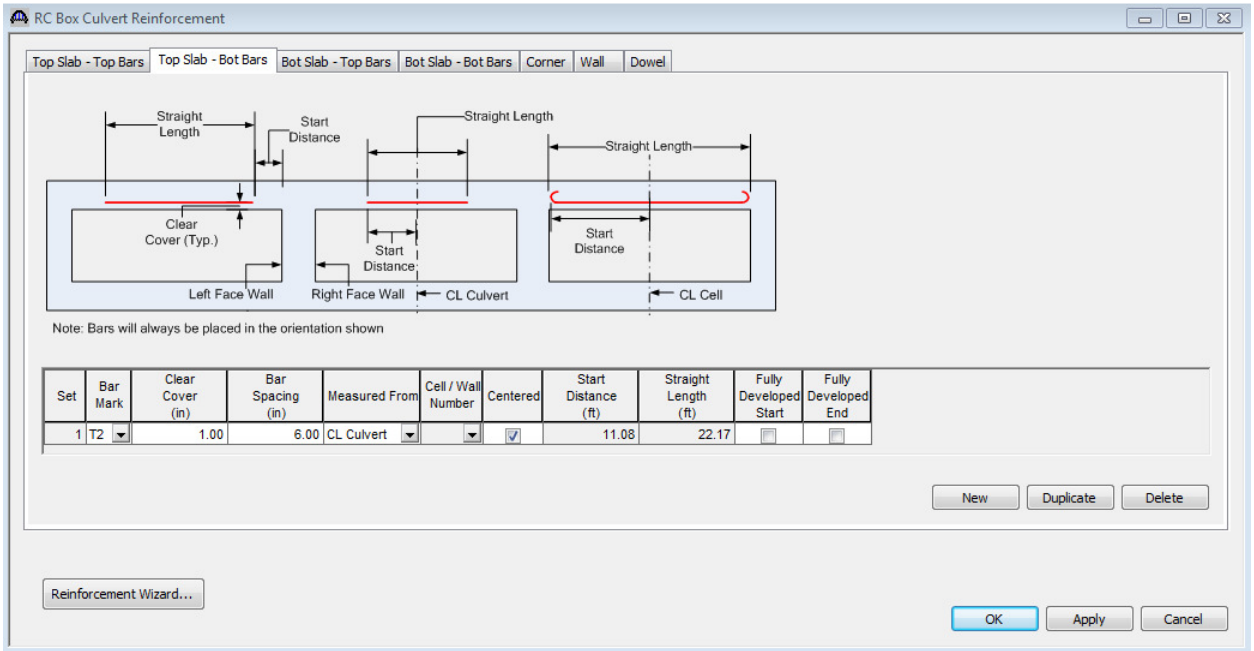


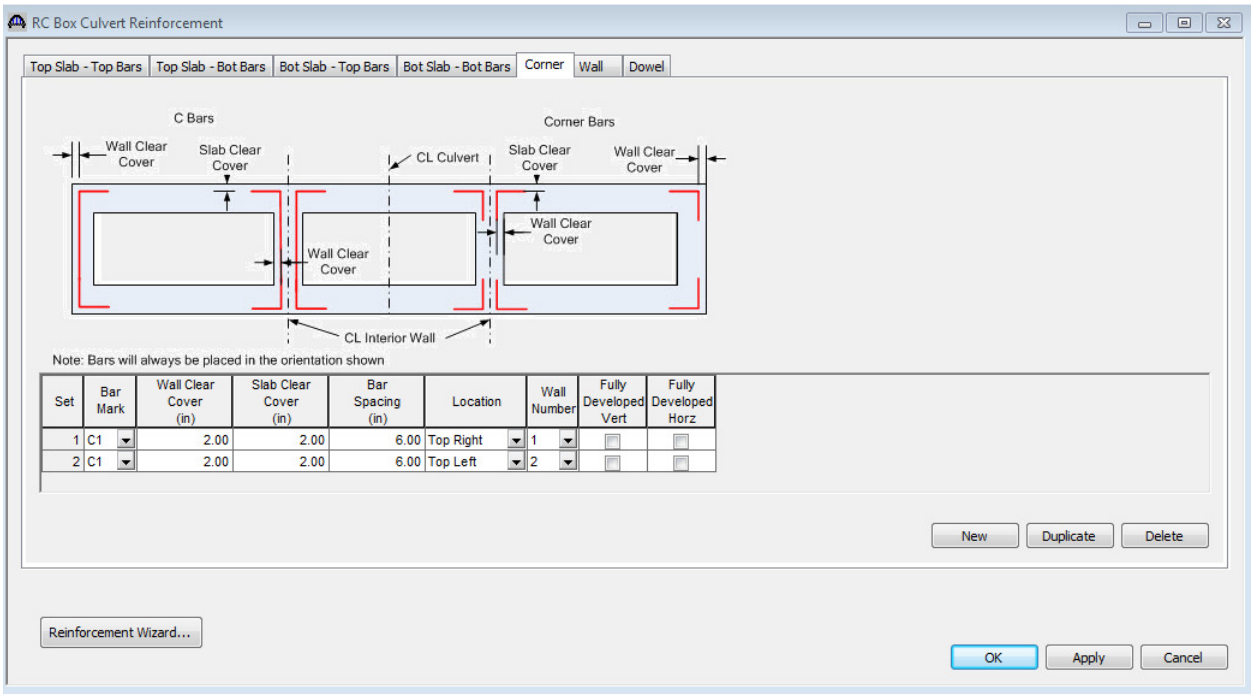
Double-click on RC Box Culvert Loads in the tree. Enter the culvert loads for Culvert Seg 1 as shown below. The wearing surface thickness includes the equivalent for the rail dead load. Click OK to save the data to memory and close the window.

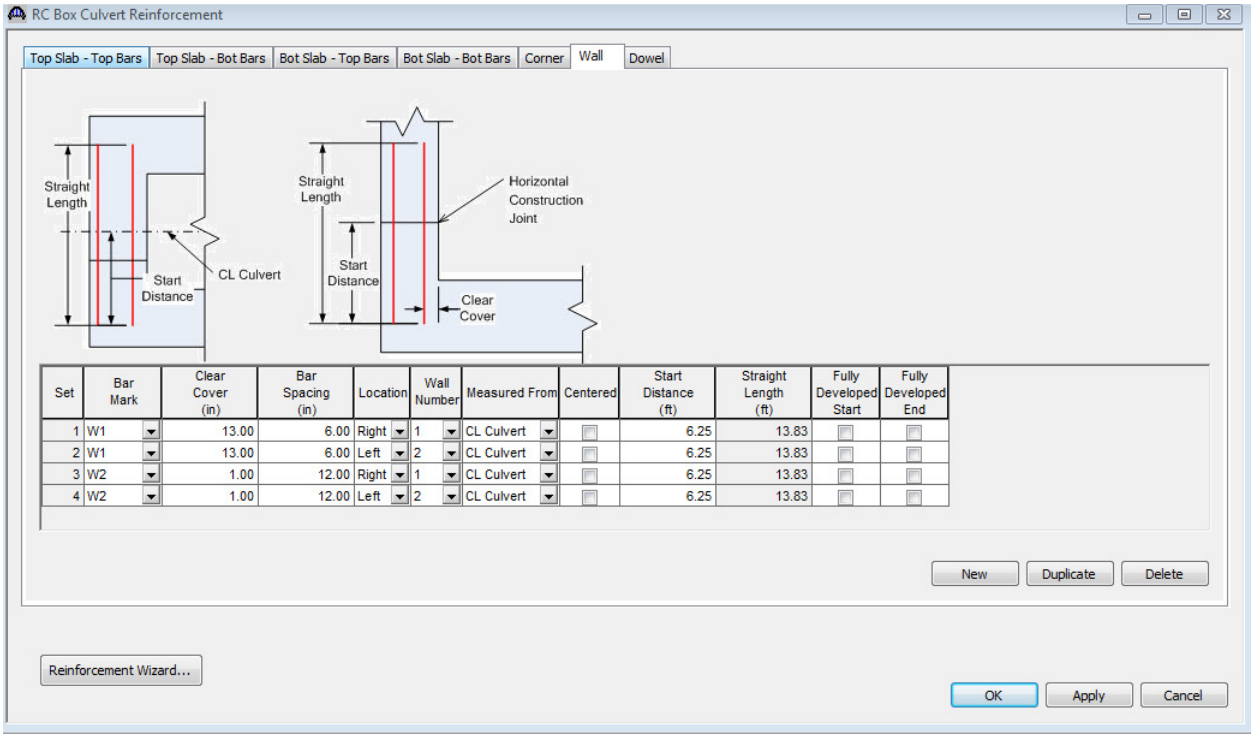


Double-click on RC Box Culvert Reinforcement in the tree. Enter the reinforcement data as shown below for each location. Click Ok to save the data to memory and close the window.

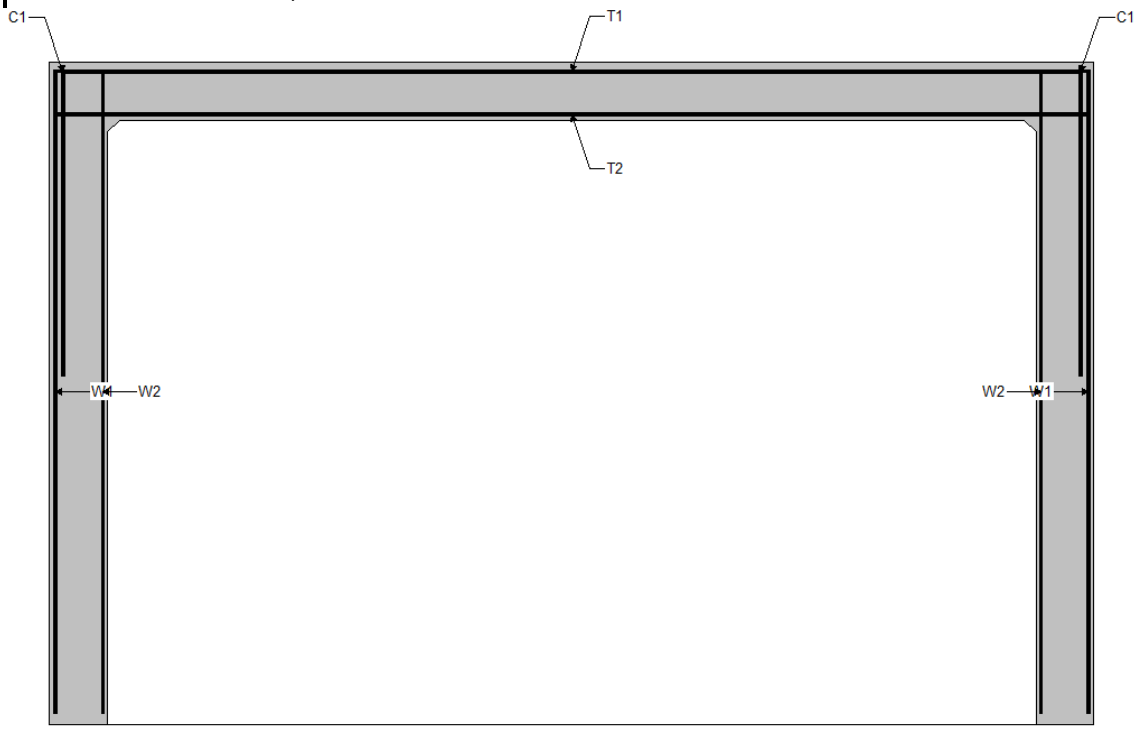





RC Box Culvert Reinforcement
Top Slab - Top Bars
Top Slab - Bot Bars
Bot Slab - Top Bars
Bot Slab - Bot Bars
Corner
Wall
Dowel
C Bars
Corner Bars
Wall Clear Cover
Slab Clear Cover
CL Culvert
Slab Clear Cover
Wall Clear Cover
Wall Clear Cover
Wall Clear Cover
Wall Clear Cover
CL Interior Wall
Note: Bars 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
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
Horizontal Construction Joint
Start Distance
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 W1 13.00 6.00 Right 1 CL Culvert 6.25 13.83
2 W1 13.00 6.00 Left 2 CL Culvert 6.25 13.83
3 W2 1.00 12.00 Right 1 CL Culvert 6.25 13.83
4 W2 1.00 12.00 Left 2 CL Culvert 6.25 13.83
New
Duplicate
Delete
Reinforcement Wizard...
OK
Apply
Cancel

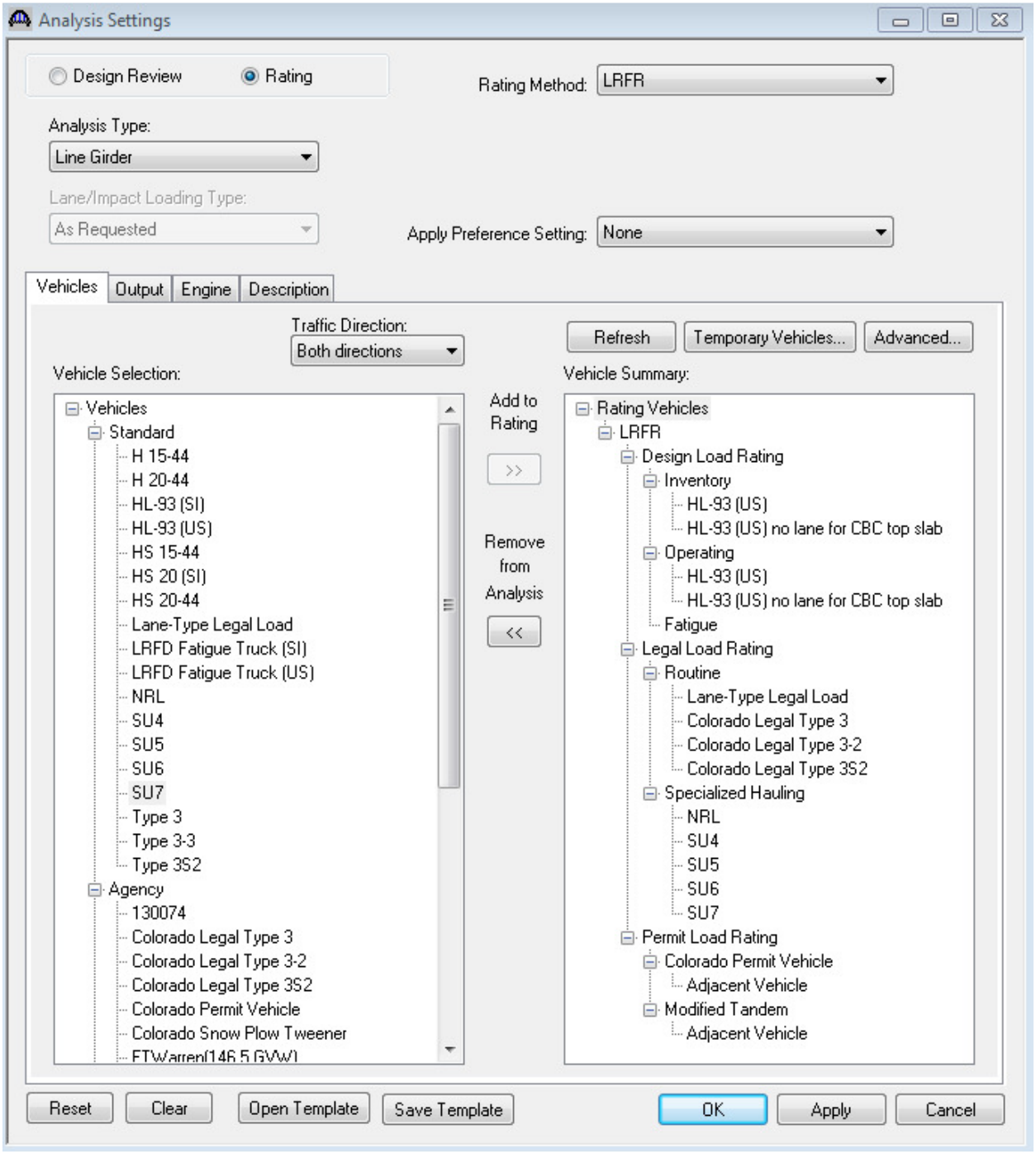
Select Bridge|Schematic to review the reinforcement data.



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

Select File|Save to save the file in BrR.

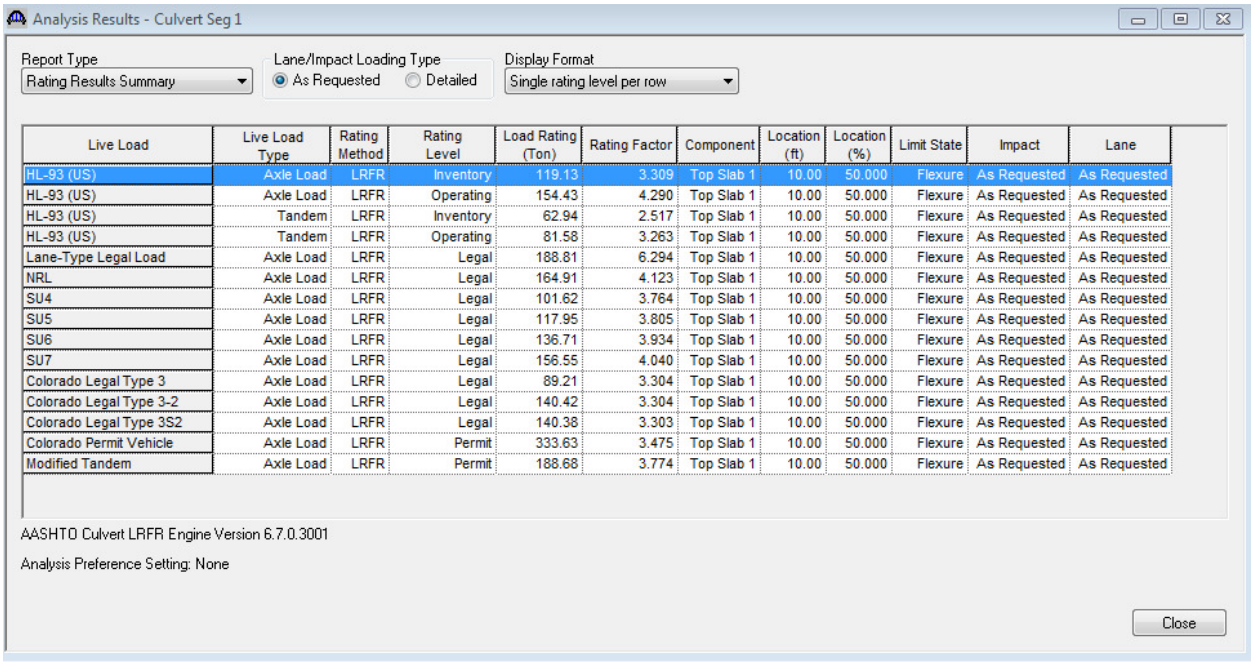
To perform LRFR Design Load Rating, open the Analysis setting window by selecting Bridge|Analysis Settings. Select LRFR as the Rating Method and specify the vehicles.



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	119.13	3.309	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Axle Load	LRFR	Operating	154.43	4.290	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Inventory	62.94	2.517	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Operating	81.58	3.263	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Lane-Type Legal Load	Axle Load	LRFR	Legal	188.81	6.294	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
NRL	Axle Load	LRFR	Legal	164.91	4.123	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU4	Axle Load	LRFR	Legal	101.62	3.764	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU5	Axle Load	LRFR	Legal	117.95	3.805	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU6	Axle Load	LRFR	Legal	136.71	3.934	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
SU7	Axle Load	LRFR	Legal	156.55	4.040	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3	Axle Load	LRFR	Legal	89.21	3.304	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3-2	Axle Load	LRFR	Legal	140.42	3.304	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Legal Type 3S2	Axle Load	LRFR	Legal	140.38	3.303	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Colorado Permit Vehicle	Axle Load	LRFR	Permit	333.63	3.475	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested
Modified Tandem	Axle Load	LRFR	Permit	188.68	3.774	Top Slab 1	10.00	50.000	Flexure	As Requested	As Requested

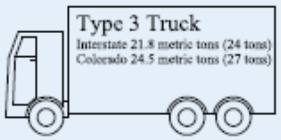
Fill out the Rating Summary Sheet using the policies and guidelines in the Bridge Rating Manual, Section 1.

COLORADO DEPARTMENT OF TRANSPORTATION
LOAD & RESISTANCE FACTOR RATING SUMMARY

Rated using:
Asphalt thickness: 1,829 mm (72 in.)
☑ Colorado legal loads
☐ Interstate legal loads

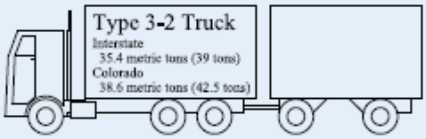
Structure #	X-02-X
State Highway #	US X
Batch I.D.	XXXX
Structure Type	CBC
Parallel Structure #	NA

Structural Member	Single Cell CBC			
	Rating Factor			
Inventory	2.5			
Operating	3.3			
	Metric tons (Tons)			
Type 3 truck	80.9 (89.2)	( )	( )	( )
Type 3S2 truck	127.3 (140.4)	( )	( )	( )
Type 3-2 truck	127.4 (140.4)	( )	( )	( )
Type SU4 truck (27T)	( )	( )	( )	( )
Type SU5 truck (31T)	( )	( )	( )	( )
Type SU6 truck (35T)	( )	( )	( )	( )
Type SU7 truck (39T)	( )	( )	( )	( )
NRL (40T)	149.6 (164.9)	( )	( )	( )
Lane-Type Legal	171.3 (188.8)	( )	( )	( )
Permit Truck **Multi-Lane D.F.**	302.6 (333.6)	( )	( )	( )



24.5 Metric tons (27.0 tons)

38.6 Metric tons (42.5 tons)



38.6 Metric tons (42.5 tons)

Comments: (T = tons)
Modified Tandem 171.2 (188.7)

Total structure length (face to face of end walls) = 50'-0"; Fill height 6'-0"; Asphalt 4 in
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
Rated with BrR 6.7 AASHTO Culvert Engine

Rated by:	Date:	Checked by:	Date:

Previous editions are obsolete and may not be used — CDOT Staff Bridge - LRFR 10/2014