AASHTOWare Bridge Rating and Design Training

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

Topics Covered
- Enter culvert description
- Perform AASHTO Culvert LRFR analysis and review results
- Culvert Design Tool
Material Properties:

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

From the Bridge Explorer, select File | New | New Bridge to create a new bridge.
Enter the following description data for the culvert. The Superstructures and Culverts checkboxes specify the types of structures the bridge contains. These checkboxes filter what to display in the Bridge Workspace tree.

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

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

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

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

![Bridge Materials - Concrete](image-url)
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.

![Bridge Materials - Reinforcing Steel](image)

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.

![Bridge Materials - Soil](image)
The Bridge Workspace tree with the three materials to be used by the culvert is shown below.
Double-click on the CULVERT DEFINITIONS folder to create a new culvert definition. Enter the Culvert Definition name as show below. The first Culvert Alternative that we create will automatically be assigned as the Existing and Current Culvert Alternative for this Culvert Definition.

Expand the tree for Culvert Def 1.
Double-click on Culvert Loads in the tree to open the Culvert Loads window. Select the checkboxes to apply soil pressure to both side of the culvert. These checkboxes are provided to allow for the case where a culvert is widened by placing another culvert directly next to it so that side does not have lateral earth pressure.

Click Ok to save the data to memory and close the window.
Double-click on the CULVERT ALTERNATIVES folder to create a new culvert alternative for Culvert Def 1. Enter the data as show below.

Select the Specs tab. AASHTO Culvert Engine is selected as the analysis module for LRFR analysis. Click Ok to save the data to memory and close the window.
Expand the tree for Culvert Alt 1.

Double-click on RC Box Culvert Geometry in the tree. Enter the data as shown below. Click Ok to save the data to memory and close the window.
Double-click on the Bar Mark Definitions folder in the tree to create a new bar mark definition for Culvert Alt 1.

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

<table>
<thead>
<tr>
<th>MARK</th>
<th>NUMBER</th>
<th>LENGTH</th>
<th>BENT</th>
<th>CUTTING DIAG.</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B801</td>
<td>415</td>
<td>11</td>
<td>3-7</td>
<td>N0</td>
<td>CORNERS</td>
</tr>
</tbody>
</table>

Bar Mark Definition

- **Name:** B801
- **Material:** Grade 60
- **Bar size:** 8
- **Bar type:** Corner

**Dimension**

- **A:** 7.583 ft
- **B:** 3.563 ft
Double-click on the Bar Mark Definitions folder in the tree to create another bar mark definition.

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

<table>
<thead>
<tr>
<th>MARK</th>
<th>NUMBER REO'D.</th>
<th>LENGTH</th>
<th>BENT</th>
<th>CUTTING DIAG.</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B802</td>
<td>400</td>
<td>7-4</td>
<td>3-7</td>
<td>N0</td>
<td>CORNERS</td>
</tr>
</tbody>
</table>

**Bar Mark Definition**

- **Name:** B802
- **Material:** Grade 60
- **Bar size:** 8
- **Bar type:** Hook
- **Dimension:**
  - A = 3.750 ft
  - B = 3.583 ft
Repeat this process for the rest of the transverse bar marks.

<table>
<thead>
<tr>
<th>MARK</th>
<th>NUMBER</th>
<th>LENGTH</th>
<th>BENT</th>
<th>CUTTING</th>
<th>LOCATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B903</td>
<td>76</td>
<td>9-0</td>
<td>N0</td>
<td>N0</td>
<td>BOTTOM SLAB TRANS.</td>
</tr>
<tr>
<td>B904</td>
<td>72</td>
<td>4-10</td>
<td>N0</td>
<td>N0</td>
<td>BOTTOM SLAB TRANS.</td>
</tr>
<tr>
<td>B505</td>
<td>124</td>
<td>25-10</td>
<td>N0</td>
<td>N0</td>
<td>BOTTOM SLAB TRANS.</td>
</tr>
<tr>
<td>B506</td>
<td>240</td>
<td>8-2</td>
<td>N0</td>
<td>N0</td>
<td>BOTTOM SLAB TRANS.</td>
</tr>
<tr>
<td>B507</td>
<td>296</td>
<td>2-0</td>
<td>N0</td>
<td>N0</td>
<td>WALLS-DOWELS VERT.</td>
</tr>
<tr>
<td>B408</td>
<td>136</td>
<td>2-0</td>
<td>N0</td>
<td>N0</td>
<td>WALLS-DOWELS VERT.</td>
</tr>
<tr>
<td>B510</td>
<td>296</td>
<td>12-4</td>
<td>N0</td>
<td>N0</td>
<td>WALLS VERT.</td>
</tr>
<tr>
<td>B411</td>
<td>136</td>
<td>13-4</td>
<td>N0</td>
<td>N0</td>
<td>WALLS VERT.</td>
</tr>
<tr>
<td>B612</td>
<td>84</td>
<td>25-10</td>
<td>N0</td>
<td>N0</td>
<td>TOP SLAB TRANS.</td>
</tr>
<tr>
<td>B613</td>
<td>160</td>
<td>8-2</td>
<td>N0</td>
<td>N0</td>
<td>TOP SLAB TRANS.</td>
</tr>
<tr>
<td>B714</td>
<td>116</td>
<td>9-0</td>
<td>N0</td>
<td>N0</td>
<td>TOP SLAB TRANS.</td>
</tr>
<tr>
<td>B715</td>
<td>112</td>
<td>4-10</td>
<td>N0</td>
<td>N0</td>
<td>TOP SLAB TRANS.</td>
</tr>
</tbody>
</table>

**Bar Mark Definition**

Name: B903

Bar Types:

- Type: Straight

Material: Grade 60

Bar size: 9

Bar type: Straight

Dimension

Δ = 9.000 ft

**Bar Mark Definition**

Name: B904

Bar Types:

- Type: Straight

Material: Grade 60

Bar size: 9

Bar type: Straight

Dimension

Δ = 4.833 ft
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Bar Mark Definition

Name: B715

Material: Grade B60
Bar size: 
Bar type: Straight

Type: Straight

Dimension

A = 4.833 ft
Double-click on the CULVERT SEGMENTS folder to create a new culvert segment for Culvert Alt 1. A culvert alternative may have one or more culvert segments. Enter the data as show below.
Expand the tree for Culvert Seg 1.
Double-click on RC Box Culvert Thickness in the tree. Enter the slab and wall thicknesses as shown below. Click Ok to save the data to memory and close the window.

![RC Box Culvert Thickness](image)

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

![Box Culvert Components](image)
Double-click on RC Box Culvert Loads in the tree. Enter the culvert loads for Culvert Seg 1 as shown below. Click Ok to save the data to memory and close the window.
Double-click on RC Box Culvert Reinforcement in the tree. Enter the reinforcement data as shown below for each location. Click Ok to save the data to memory and close the window.
Note: Bars will always be placed in the orientation shown.

<table>
<thead>
<tr>
<th>Set</th>
<th>Bar Mark</th>
<th>Clear Cover (in)</th>
<th>Bar Spacing (in)</th>
<th>Measured From</th>
<th>Cell / Wall Number</th>
<th>Centered</th>
<th>Start Distance (ft)</th>
<th>Straight Length (ft)</th>
<th>Fully Developed Start</th>
<th>Fully Developed End</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>B505</td>
<td>2.00</td>
<td>13.00</td>
<td>CL Culvert</td>
<td></td>
<td>✓</td>
<td>12.92</td>
<td>25.83</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>2</td>
<td>B506</td>
<td>2.00</td>
<td>13.00</td>
<td>CL Cell</td>
<td>1</td>
<td>✓</td>
<td>4.03</td>
<td>6.17</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>3</td>
<td>B506</td>
<td>2.00</td>
<td>13.00</td>
<td>CL Cell</td>
<td>2</td>
<td>✓</td>
<td>4.08</td>
<td>8.17</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
Select Bridge | Schematic to review the reinforcement data.

The description of the two-cell reinforced concrete box culvert is complete.
Perform AASHTO Culvert LRFR analysis and review results

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

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

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

To review detailed rating results at the controlling location, select Bridge | Specification Checks to open the Specification window. Expand the tree for Top Slab 1 and select the 8.40 ft. folder.
Double-click on the 6A.4.2.1 Concrete Flexure specification reference to open the Spec Check Detail window.

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

Select the CULVERT ALTERNATIVES folder in the Bridge Workspace tree. Select Bridge | Curvert Design Tool to open the RC Box Culvert Design Tool. Enter the data as shown below.
Click Next and enter the data as shown below.
Click Finish to start the design process. Click Ok to close the RC Box Culvert Design Tool Progress window after the design is completed.

The Culvert Design Tool Results window is shown below. Click Apply to accept the design and click Close to close the window.
The Bridge Workspace tree with the Design Alt 1 is shown below.
Select Design Alt 1 RC Box Culvert Reinforcement in the tree. Select Bridge | Schematic to review the reinforcement data.