



Metal Culvert Ratings Demo and SSI Implementation Update

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2025 Rating and Design Bridge User Group Meeting
Boise, ID | August 12-13, 2025

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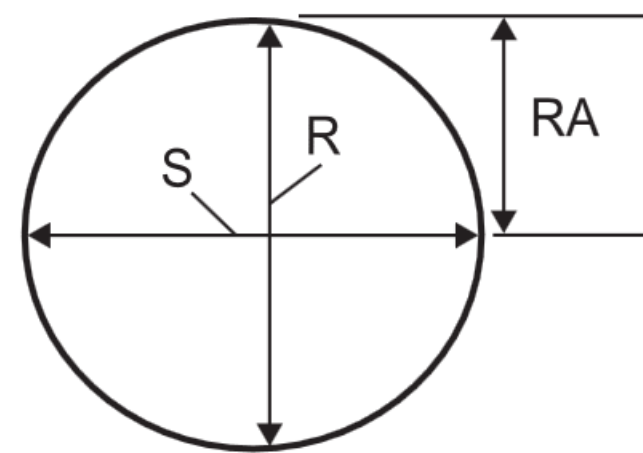
Metal Culvert Ratings Demo

Metal Pipe Culvert and Metal Box Culvert

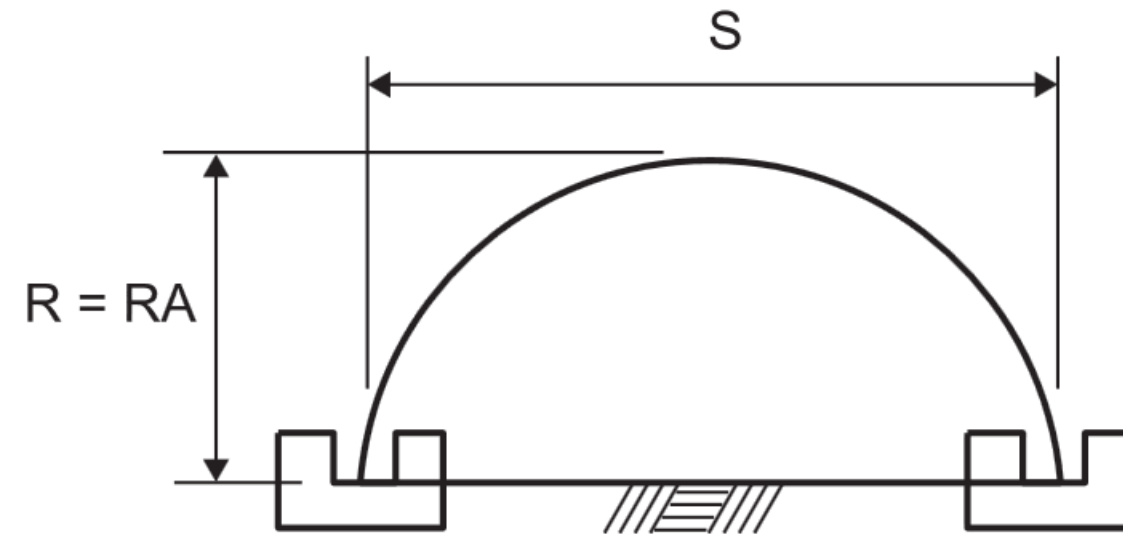
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Metal Pipe Culvert Ratings

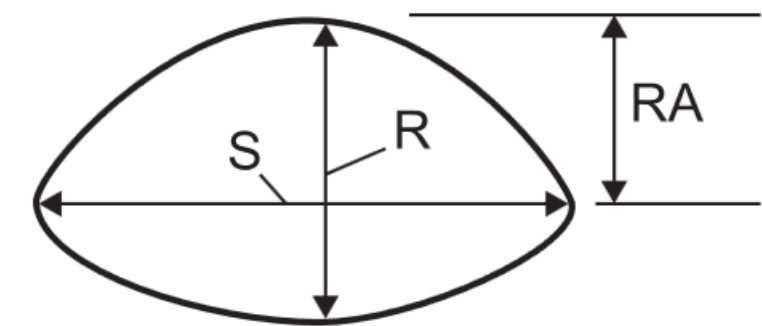
- Introduced with BrDR version 7.3.0.
- LFR and LRFR rating methods are supported.
- Rated for wall capacity and plastic moment capacity
- Aluminum and Steel material types.
- Single and multilane loading options.



Circular



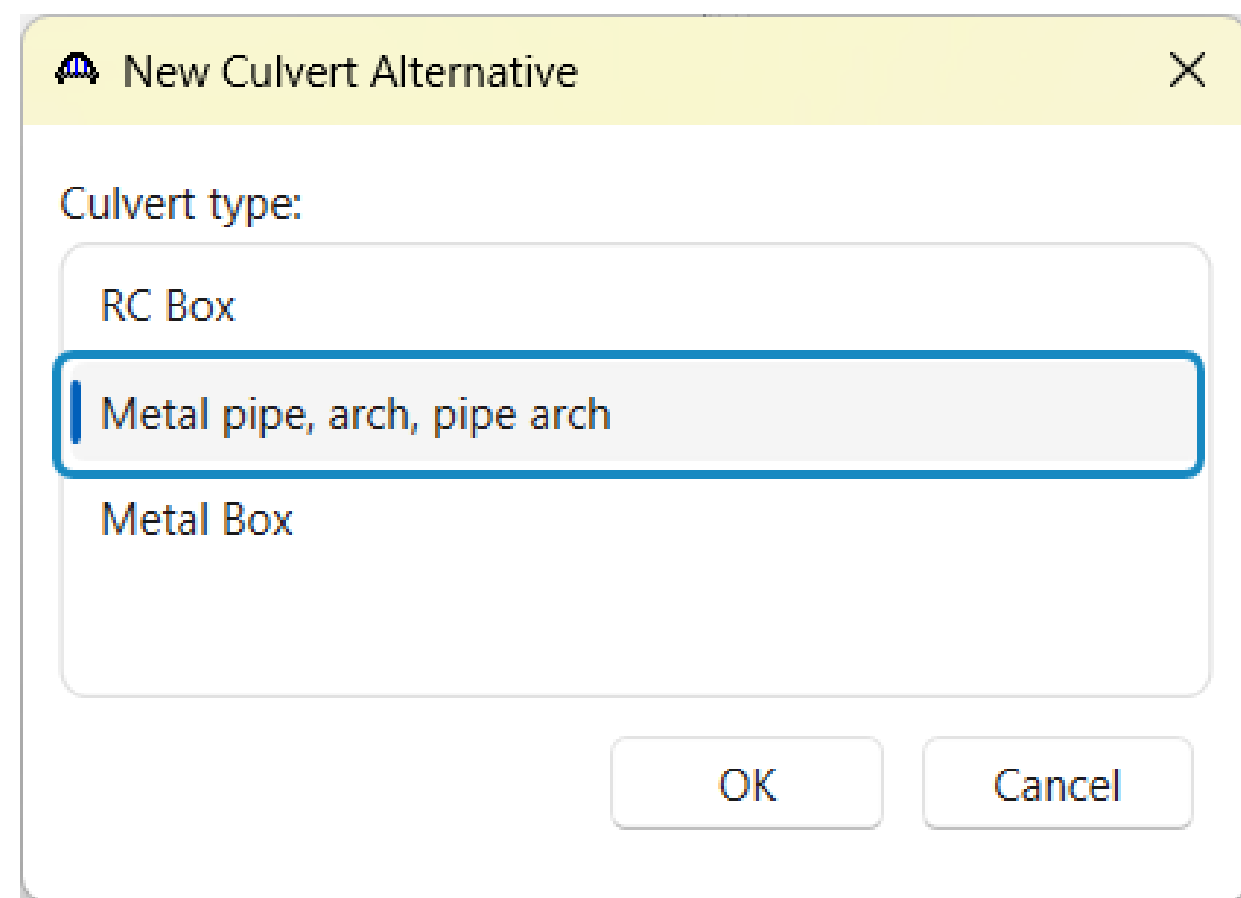
Arch



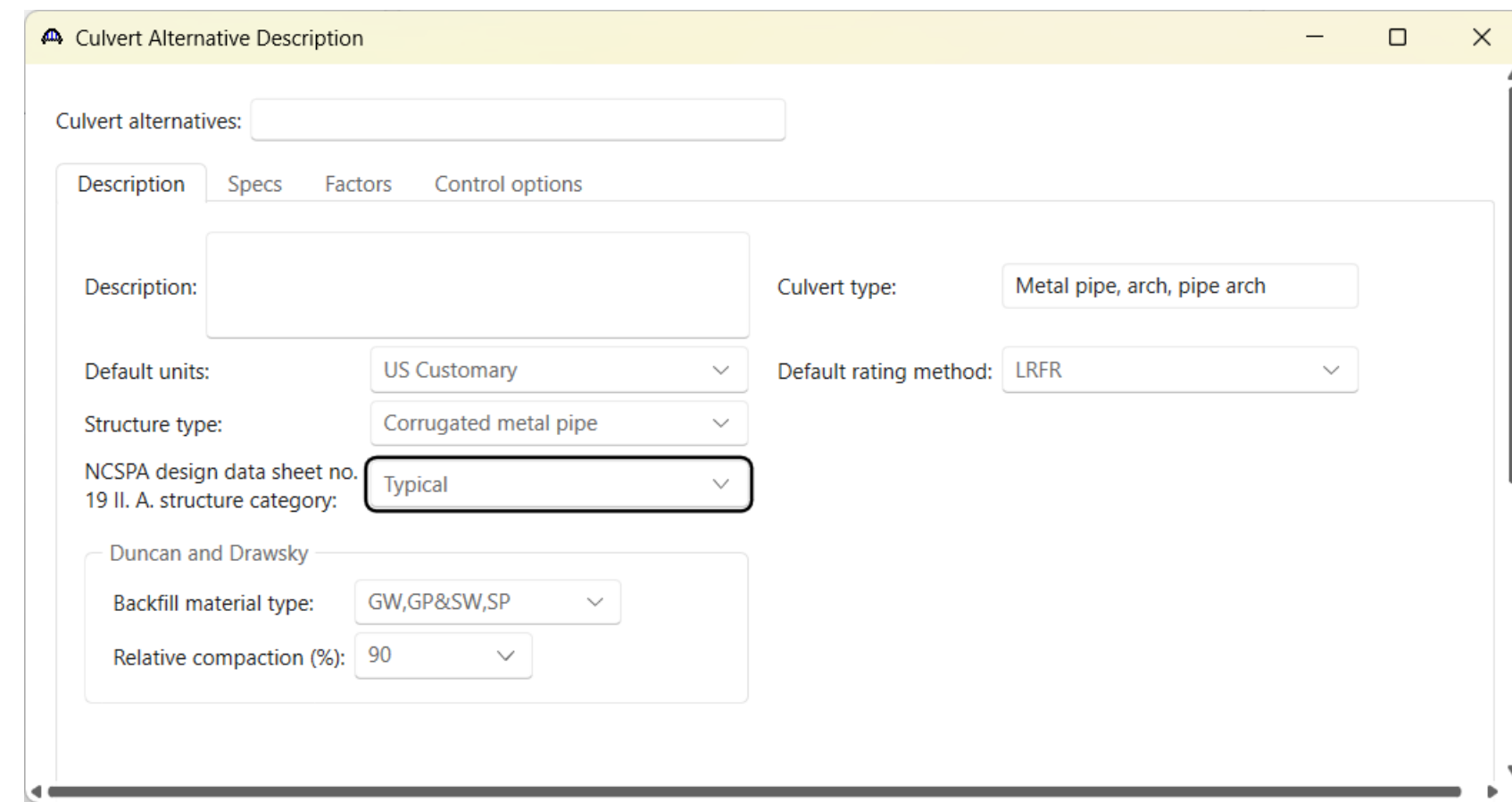
Pipe arch

Metal Pipe Culvert Ratings – Culvert Alternative

Define a metal pipe culvert alternative with the “Metal pipe, arch, pipe arch” culvert type.



The "New Culvert Alternative" dialog box is shown. It has a title bar with a yellow background and a close button. The main area is titled "Culvert type:" and contains a list of three options: "RC Box", "Metal pipe, arch, pipe arch", and "Metal Box". The "Metal pipe, arch, pipe arch" option is highlighted with a blue border. At the bottom, there are "OK" and "Cancel" buttons.



The "Culvert Alternative Description" dialog box is shown. It has a title bar with a yellow background and standard window controls. The main area is divided into four tabs: "Description", "Specs", "Factors", and "Control options". The "Description" tab is active. It contains several fields: "Culvert alternatives:" (a text box), "Description:" (a text box), "Culvert type:" (a dropdown menu with "Metal pipe, arch, pipe arch" selected), "Default units:" (a dropdown menu with "US Customary" selected), "Structure type:" (a dropdown menu with "Corrugated metal pipe" selected), "NCSPA design data sheet no. 19 II. A. structure category:" (a dropdown menu with "Typical" selected), "Duncan and Drawsky" (a section header), "Backfill material type:" (a dropdown menu with "GW,GP&SW,SP" selected), and "Relative compaction (%):" (a dropdown menu with "90" selected). At the bottom, there are "OK" and "Cancel" buttons.

Metal Pipe Culvert Ratings – Control Options

Consider Duncan and Drawsky plastic moment: Select this option to load rate a culvert alternative using the plastic moment capacity in addition to the wall capacity. The plastic moment capacity is computed according to the method described in *Design Procedures for Flexible Metal Culverts* by J. M. Duncan and R. H. Drawsky (1983).

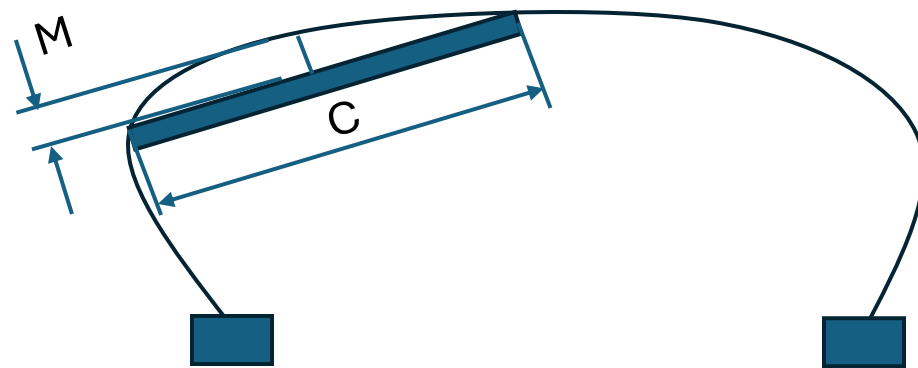
Consider multiple loaded lanes: Select this option to consider multiple side-by-side lanes in the live load pressure calculations. The program determines the number of lanes based on the clear roadway width.

Ignore effects from negligible LL: Select this option to skip rating when the live load pressure at the depth of the culvert is less than 10% of the total pressure at the depth of the culvert.

Description	Specs	Factors	Control options
LRFR			
<input checked="" type="checkbox"/> Consider Duncan and Drawsky plastic moment			
<input checked="" type="checkbox"/> Consider multiple loaded lanes			
<input checked="" type="checkbox"/> Ignore effects from negligible LL			
LFR			
<input checked="" type="checkbox"/> Consider Duncan and Drawsky plastic moment			
<input checked="" type="checkbox"/> Consider multiple loaded lanes			
<input checked="" type="checkbox"/> Ignore effects from negligible LL			

Metal Pipe Culvert Ratings – Metal Pipe Culvert Geometry

- Actual Top Radius input is required for “Long Span” or “Unsymmetrical or Deflect over 5%” structure categories.
- Field measurement calculation:



$$R = \frac{M}{2} + \frac{C^2}{8M}$$

Metal Pipe Culvert Geometry

Circular Arch Pipe Arch

Span length (S): 10 ft

Rise (R): 10 ft

Rise above haunch (RA): 5 ft

Actual top radius

☒ Design Plans ☐ Field measurement

Straight edge length (C): ft

Mid-ordinate (M): ft

Actual top radius: ft Compute

OK Apply Cancel

Metal Pipe Culvert Ratings – Metal Pipe Culvert Properties

- Note: Some pipe library items have different seam strengths for single or double rivets. When copying these items from the library, the program will open a prompt to select the appropriate seam strength.

Metal Pipe Culvert Properties

Structure type: Corrugated metal pipe

Material type: ☒ Steel ☐ Aluminum

Material: Steel - Corrugated

Section properties

Copy from library

Name: 5 x 1 Corrugated stl. pipe

Gage:

Thickness: 0.109 in

A: 1.39 in²/ft

r: 0.36770004 in

I: 15.65 in⁴/in x 10⁻³

Mp: 2.66 kip-ft/ft

Seam strength: 62 kip/ft

Condition

Pipe crown deflection: 0 %

Buckling strength adjustment factor: 1

Seam strength adjustment factor: 100 %

Percent thickness remaining: 100 %

OK

Apply

Cancel

Library Data: Metal Pipe Culvert - Steel Corrugated Metal Pipe

Name	Description	Library	Units	Gage	Thickness	A	r	I	Mp	Rivet size	Single rivet seam strength	Double rivet seam strength
2 2/3 x 1/2 Corrugated stl. pipe		Standard	US Customary	8	0.168	2.133	0.1795	5.725	1.11	0.375	25.6	51.3
2 2/3 x 1/2 Corrugated stl. pipe								5.533	0.9	0.375	24.5	49

Seam Strength

Select the value of the seam strength to copy:

☒ Single rivet:

25.6

kip/ft

☐ Double rivet:

51.3

kip/ft

OK

Cancel

Metal Pipe Culvert Ratings – Metal Pipe Culvert Loads

Average Depth of Fill (H): Enter depth of fill including any wearing surface. Used for dead load calculations.

Minimum Cover Depth (Hmin): Program validates minimum cover against AASHTO requirements. Used for plastic moment live load calculations.

Water Height: Input the water height measured from the top of the culvert to compute the soil load on the culvert.

Clear Roadway Width: Width of travelway to determine the number of lanes for multilane loading.

Pavement Reduction Factor: Defaults to 100%. A value less than 100% indicates a reduction in the applied live load force.

Metal Pipe Culvert Loads

Clear roadway width

ELEVATION

Flexible Pavement

Base Course

Subbase

H

Hmin

Flexible Pipe

Rigid Pavement

Base Course

Subbase

H = Hmin

Flexible Pipe

Average depth of fill (H):

2

ft

Minimum cover depth (Hmin):

2

ft

Water height:

0

ft

Clear roadway width:

24

ft

Pavement reduction factor:

%

Wearing surface density:

0

pcf

Wearing surface thickness:

0

in

☐ Thickness field measured (DW = 1.25 if checked)

Comment:

OK

Apply

Cancel

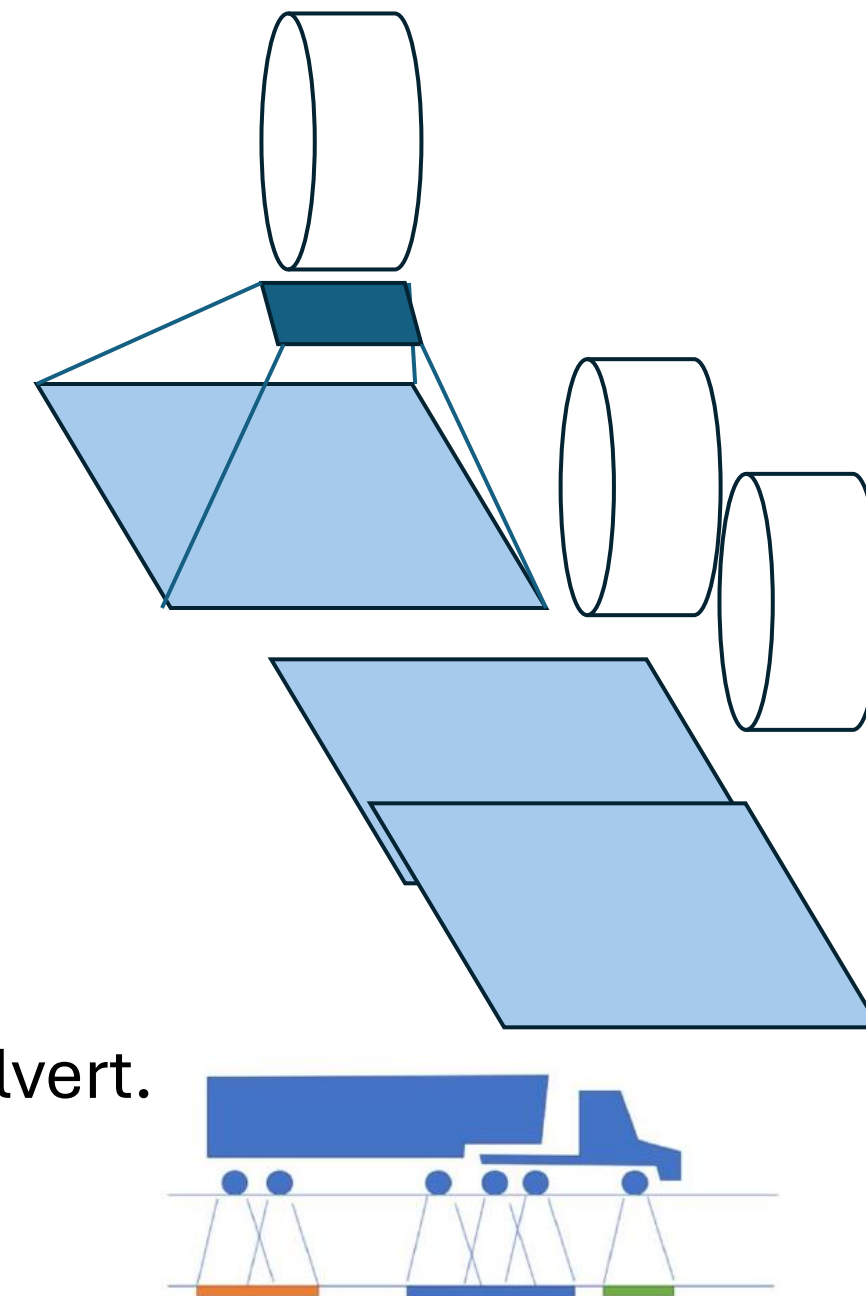
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Metal Pipe Culvert Ratings – Live Load Thrust Calculation

1. Determine wheel contact patch on surface.
2. Distribute live load pressure through fill to depth of culvert.
3. Combine regions of influence from adjacent axles.
4. Find critical axle group for maximum pressure at depth of culvert.



Metal Pipe Culvert Ratings – Live Load Thrust Calculation

```
=====
Vehicle: HL-93 (US) - Truck - DesignInv - STR-I
=====

Tire Patch Length (lt) = 10.00 (in) for HL-93 loading

Wheel Load Distribution to Critical Axle Group

Average Depth of Fill (H)          = 2.00 (ft)
Span Length (S)                    = 10.00 (ft)

Sa-crit = H*LLDF + lt              = 3.13 (ft)

Axle No.    Total Axle Load    Axle Spacing    Pressure
            (kip)              (ft)            (kip/ft)
-----
1           8.00                ---            2.55
2          32.00              14.00          10.21
3          32.00              14.00          10.21

Axle No.    Total Axle Load    Axle Spacing    wt    sw    Ww
            (kip)              (ft)            (ft)  (ft)  (ft)
-----
2          32.00                ---            1.67  6.00  4.57

Single Lane Results:














Total area at depth H (A_LL)          = 14.31 (ft^2)
Live load patch length at depth (lw)   = 3.13 (ft)
Total live load for all interacting wheels (P) = 16.00 (kip)

Live Load Vertical Crown Pressure (Pl) =  $\frac{P * (1 + IM / 100) * MPF}{A_{LL}}$  (3.6.1.2.6b-7)

No. Lanes    MPF    Required Depth    Total Width    Load From All    Live Load    Live Load
            (ft)    For Interaction    At Depth      Interacting Wheels    Area    Pressure
            (ft)                    (ft)            (kip)          (ft^2)    (ksf)
-----
1           1.20                ---            4.57            16.00     14.31     1.67
```

Metal Pipe Culvert Ratings – Results

Specification Check Detail

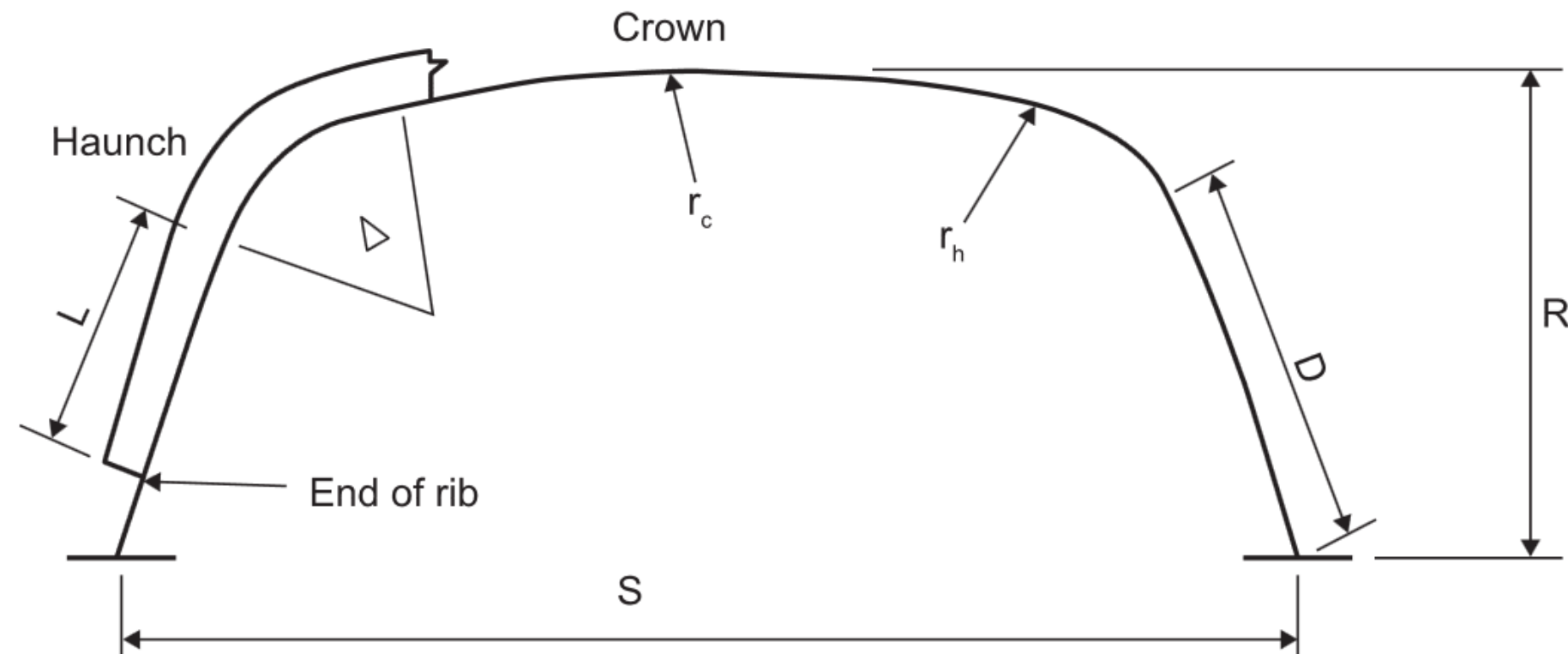
Specification reference	Limit State	Flex. Sense	Pass/Fail
 12.7.2 Safety Against Structural Failure		N/A	General Comp.
 12.7.2.2.DL Dead Load Thrust		N/A	General Comp.
 12.7.2.2.LL Live Load Thrust		N/A	General Comp.
 12.7.2.4 Resistance to Buckling		N/A	General Comp.
 3.6.2.2 Culvert Dynamic Load Allowance		N/A	General Comp.
 6A.10.10.3a Wheel Load Distribution		N/A	General Comp.
 6A.10.4 Culvert Load Rating Equation - Duncan and Drawsky Plastic Moment		N/A	Passed
 6A.10.4 Culvert Load Rating Equation - Wall Capacity		N/A	Passed
 Culvert Geometry		N/A	General Comp.
 K4 Factor - Equivalent Lane Load		N/A	General Comp.
 Max Moment At Quarter Point, H = 0		N/A	General Comp.
 Max Moment At Quarter Point, H = Hmin		N/A	General Comp.
 Secant Modulus Backfill Material		N/A	General Comp.

Tabular Results

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Limit State	Impact	Lane
HL-93 (US)	Axle Load	LRFR	Inventory	39.43	1.095	STRENGTH-I Plastic Moment	As Requested	As Requested
HL-93 (US)	Tandem	LRFR	Inventory	50.47	1.402	STRENGTH-I Plastic Moment	As Requested	As Requested

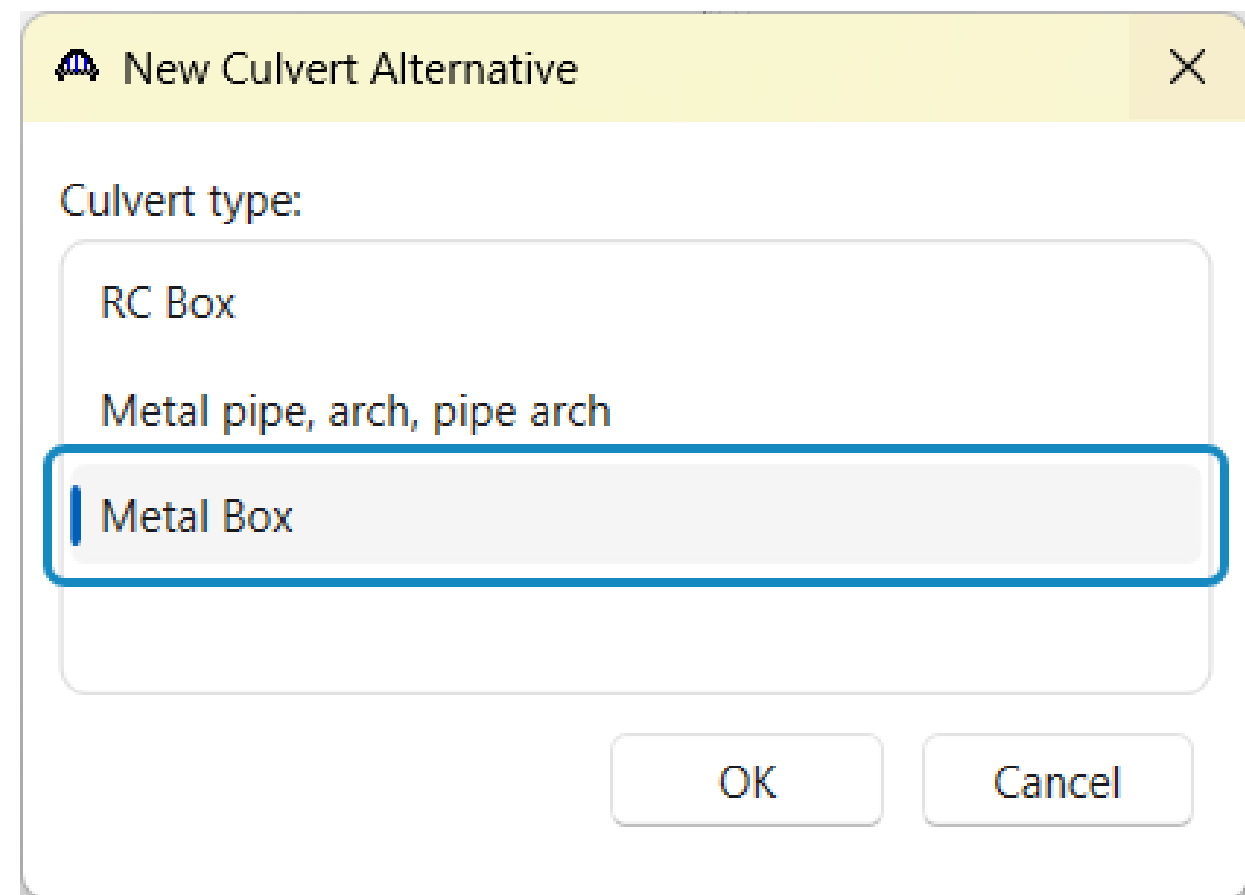
Metal Box Culvert Ratings

- Introduced with BrDR version 7.3.0.
- LFR and LRFR rating methods are supported.
- Rated for plastic moment capacity.
- Aluminum and Steel material types.

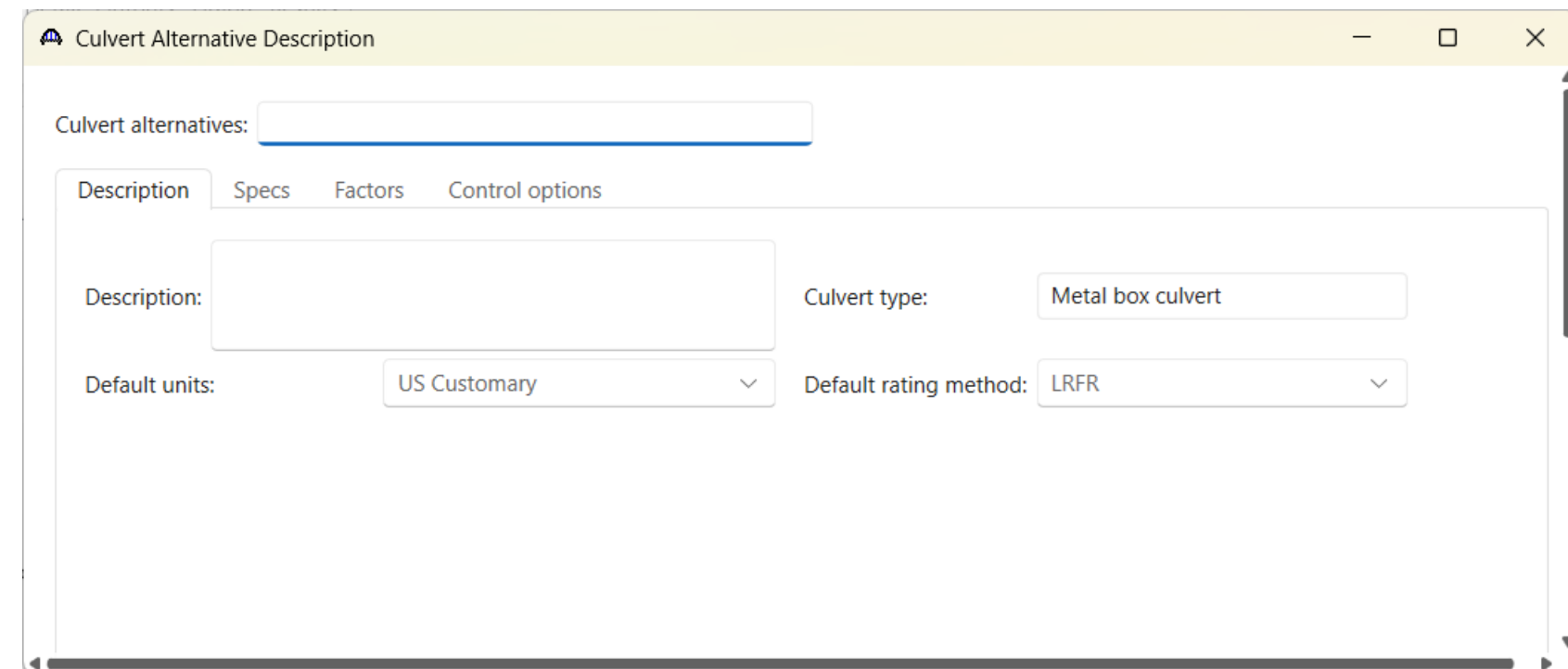


Metal Box Culvert Ratings – Culvert Alternative

Define a metal box culvert alternative with the “Metal Box” culvert type.



The "New Culvert Alternative" dialog box is shown. It has a title bar with a small icon and a close button. The main area is labeled "Culvert type:" and contains a list of options: "RC Box", "Metal pipe, arch, pipe arch", and "Metal Box". The "Metal Box" option is highlighted with a blue border. At the bottom, there are "OK" and "Cancel" buttons.



The "Culvert Alternative Description" dialog box is shown. It has a title bar with a small icon and standard window controls. The main area is divided into tabs: "Description", "Specs", "Factors", and "Control options". The "Description" tab is active. It contains a "Culvert alternatives:" text box at the top. Below it, there are four fields: "Description:" (a large text box), "Culvert type:" (a dropdown menu showing "Metal box culvert"), "Default units:" (a dropdown menu showing "US Customary"), and "Default rating method:" (a dropdown menu showing "LRFR").

Metal Box Culvert Ratings – Control Options

Ignore effects from negligible LL: Select this option to skip rating when the live load pressure at the depth of the culvert is less than 10% of the total pressure at the depth of the culvert.

DescriptionSpecsFactorsControl options

LRFR

☐ Ignore effects from negligible LL

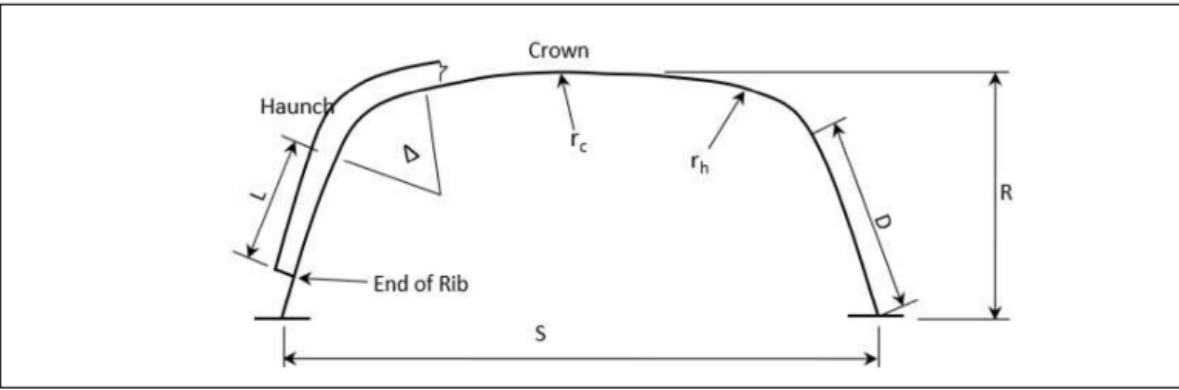
LFR

☐ Ignore effects from negligible LL

Metal Box Culvert Ratings – Metal Box Culvert Geometry

- LRFR: Review AASHTO LRFD 12.9.4 for geometric requirements of box culverts.
- LFR: Review AASHTO STD 12.8.2 for geometric requirements of box culverts.

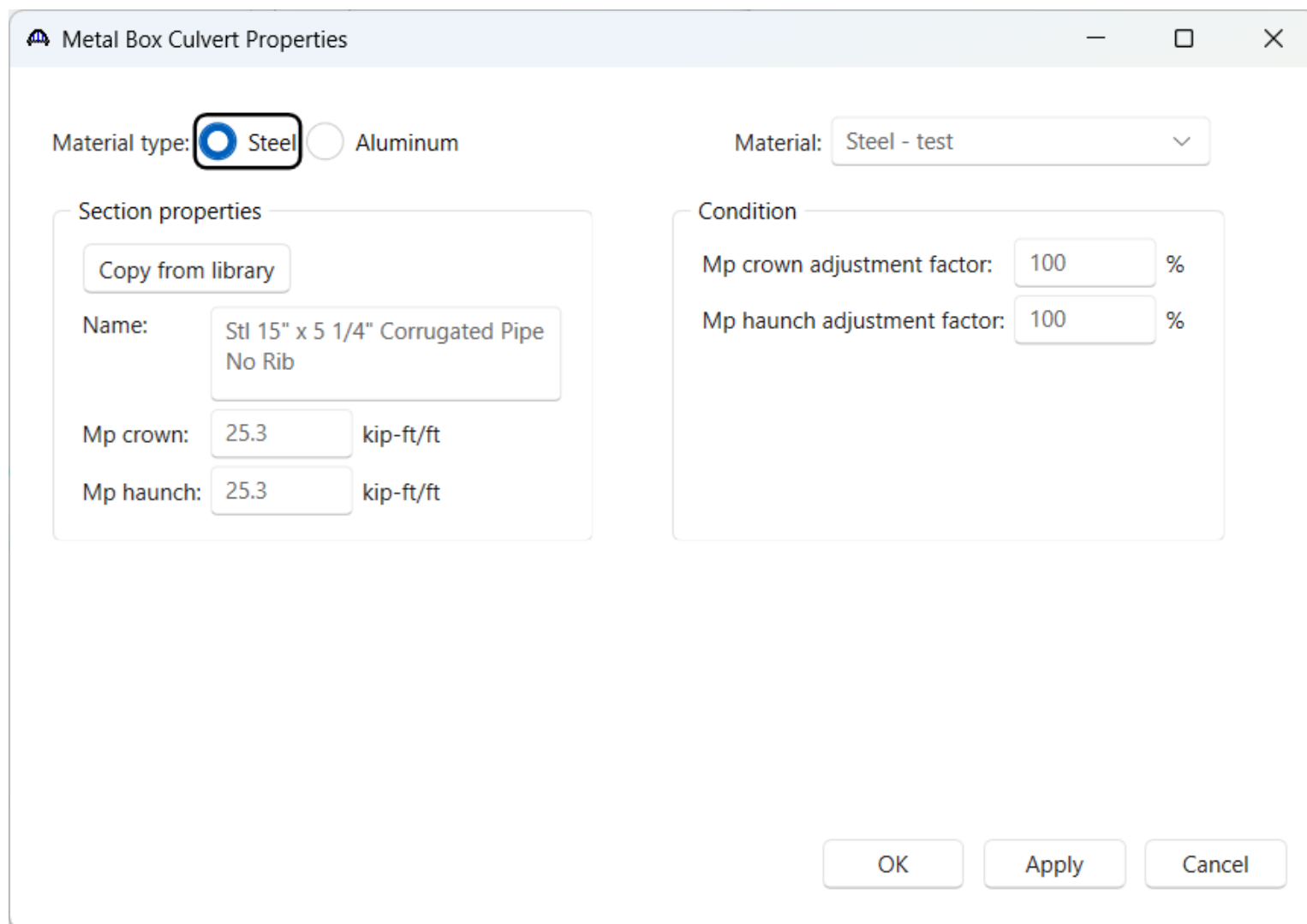
Metal Box Culvert Geometry



Span (S): 20 ft Delta: 60 Degrees
Rise (R): 6 ft D: 4 ft
rc: 20 ft L: 3 ft
rh: 5 ft Height of cover (H): 3 ft
Pavement reduction factor: 100 %
Comment:

OK Apply Cancel

Metal Box Culvert Ratings – Metal Box Culvert Properties

A screenshot of the 'Metal Box Culvert Properties' dialog box. The window has a title bar with a small icon, the text 'Metal Box Culvert Properties', and standard minimize, maximize, and close buttons. The main area is divided into two columns. The left column contains 'Material type' with radio buttons for 'Steel' (selected) and 'Aluminum', and a 'Section properties' group box. Inside the group box is a 'Copy from library' button, a 'Name' field with the text 'Stl 15" x 5 1/4" Corrugated Pipe No Rib', and two rows of input fields: 'Mp crown: 25.3 kip-ft/ft' and 'Mp haunch: 25.3 kip-ft/ft'. The right column contains a 'Material' dropdown menu set to 'Steel - test', and a 'Condition' group box with two rows of input fields: 'Mp crown adjustment factor: 100 %' and 'Mp haunch adjustment factor: 100 %'. At the bottom right are three buttons: 'OK', 'Apply', and 'Cancel'.

Metal Box Culvert Properties

Material type: ☒ Steel ☐ Aluminum

Material: Steel - test

Section properties

Copy from library

Name: Stl 15" x 5 1/4" Corrugated Pipe No Rib

Mp crown: 25.3 kip-ft/ft

Mp haunch: 25.3 kip-ft/ft

Condition









Mp crown adjustment factor: 100 %

Mp haunch adjustment factor: 100 %

OK Apply Cancel

Metal Pipe Culvert Ratings – Results

Specification Check Detail

Specification reference	Limit State	Flex. Sense	Pass/Fail
 12.9.4.2.C Moments due to Factored Loads - C1 Factor		N/A	General Comp.
 12.9.4.2.DL Moments due to Factored Loads - Dead Load		N/A	General Comp.
 12.9.4.2.K Moments due to Factored Loads - K Factors		N/A	General Comp.
 12.9.4.2.LL Moments due to Factored Loads - Live Load		N/A	General Comp.
 12.9.4.3 Plastic Moment Resistance		N/A	General Comp.
 12.9.4.4 Crown Soil Cover Factor		N/A	General Comp.
 3.6.2.2 Culvert Dynamic Load Allowance		N/A	General Comp.
 6A.10.4 Culvert Load Rating Equation - Plastic Moment		N/A	Passed

Tabular Results

	Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Limit State	Impact	Lane
	HL-93 (US)	Axle Load	LRFR	Inventory	41.67	1.157	STRENGTH-I Plastic Moment	As Requested	As Requested
	HL-93 (US)	Tandem	LRFR	Inventory	53.10	1.475	STRENGTH-I Plastic Moment	As Requested	As Requested



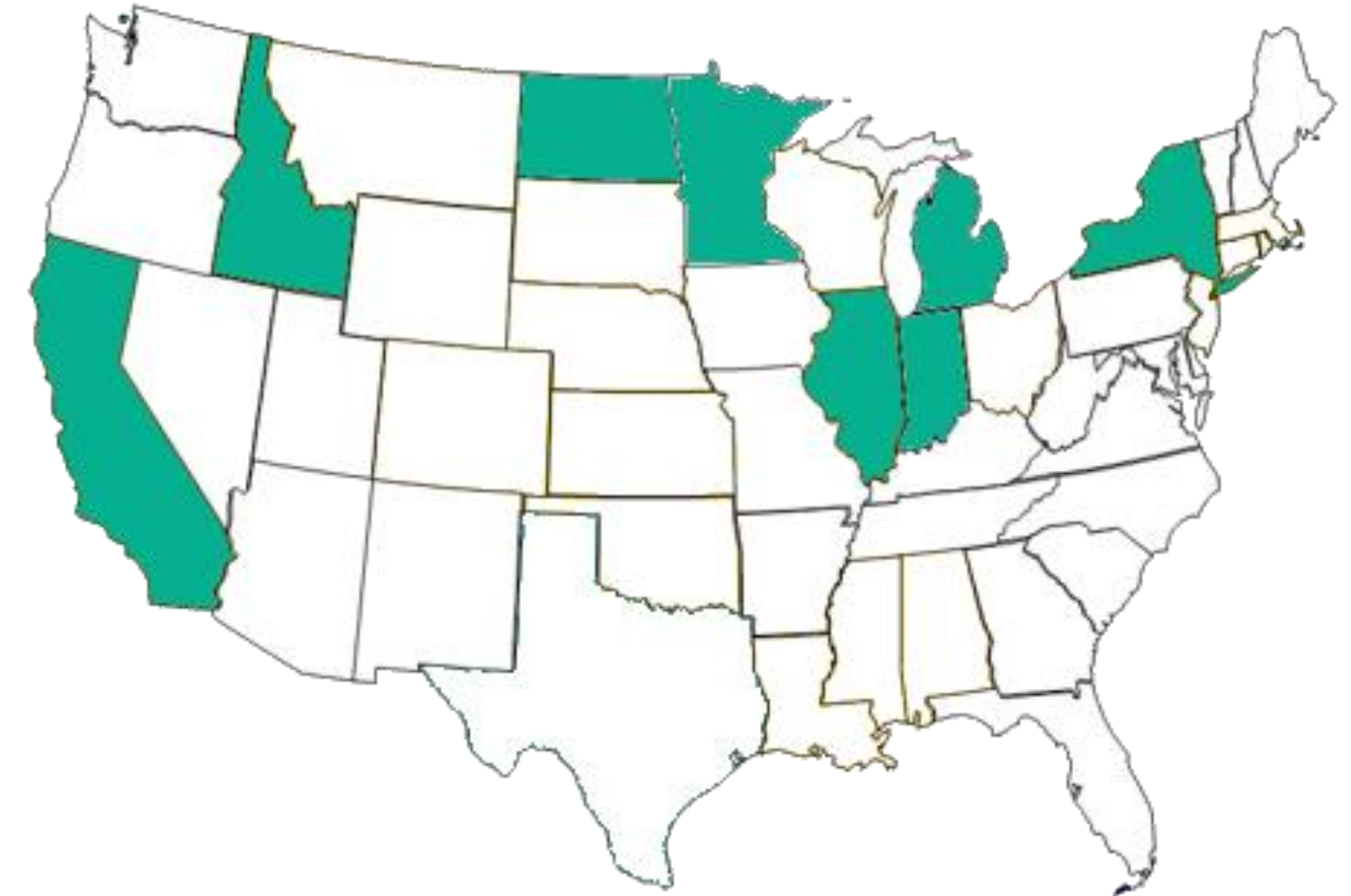
SSI Implementation Update

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SSI Implementation Update

Culvert TAG participants – 9 DOTs, 3 consultants

- Mike Johnson, Idaho TD, Chair
- Matt Luger, North Dakota DOT, Vice-Chair
- Mark Mlynarski, ProMiles
- Ruben Boehler, Illinois DOT
- Yihong Gao, Minnesota DOT
- Jennifer Hart, Indiana DOT
- Ratan Huda, New York DOT
- Spencer Koehler, Illinois DOT
- Don Tempinson, Michigan DOT
- Richard Tsang, CalTrans
- Elizabeth Befikadu, AI Engineers
- Nevil Gomes, ECMS
- Damian Silverstrim, AI Engineers



Early stages–Phase I – Version 7.8 (2026)

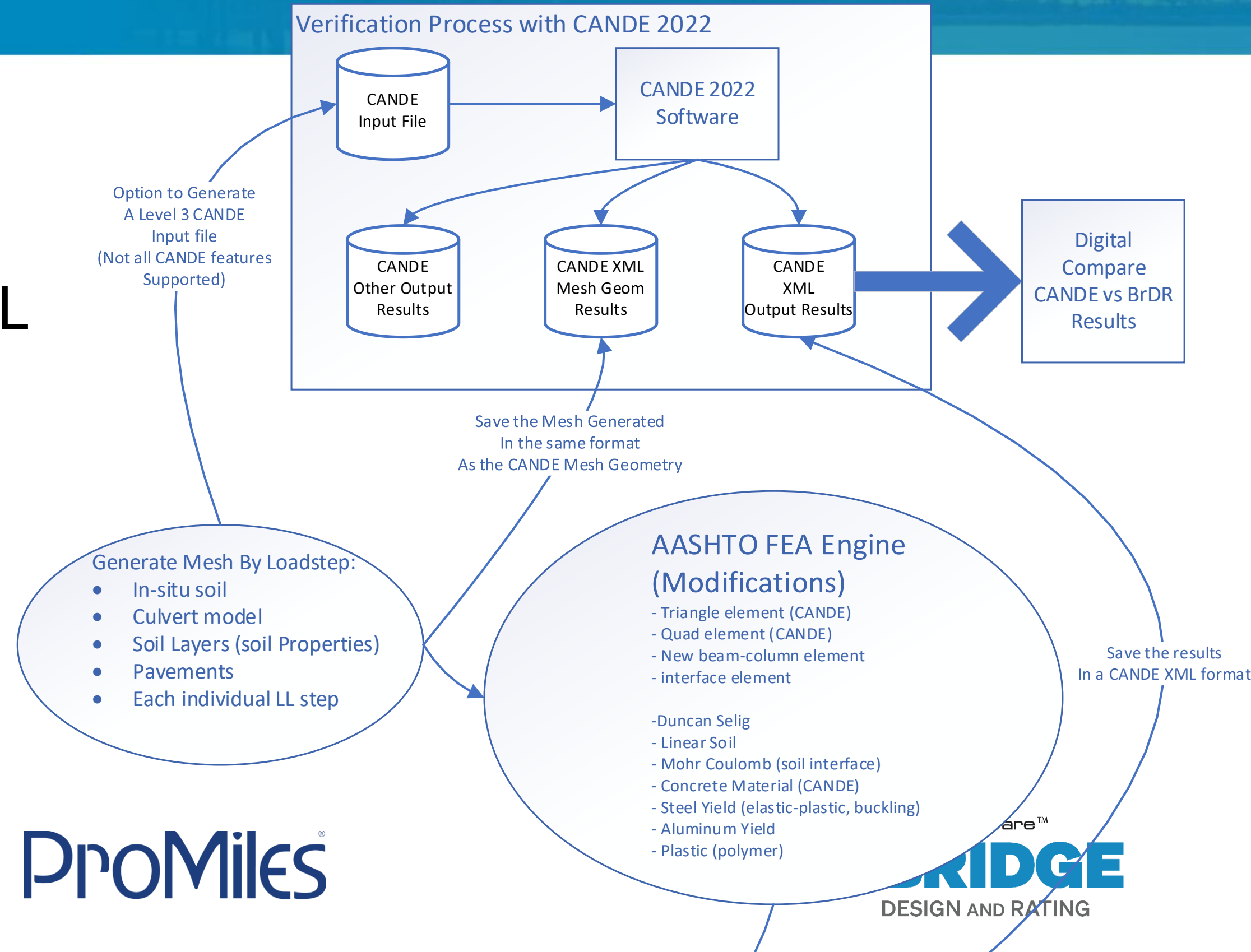
- Developing Elements similar to CANDE
- Using modern programming techniques and practices
 - (**NOT** integrating the existing CANDE into BrDR – just the techniques)
- Creating the analysis engine to run Level 3 models

Early stages–Phase I – Version 7.8 (2026)

- Validation with CANDE
 - Tools for comparing the results of existing CANDE models
- Engine included in version 7.8 of the BrDR software
 - Will NOT be available to users (no user interface)
 - User Interface will be provided in later versions (Phase II)

Early stages–Phase I – Version 7.8 (2026)

- Validation Process
- Use new engine with SSI elements
- Produce output in CANDE XML format
- Digital (or graphical) comparison of results for various models



Early stages–Phase I – Version 7.8 (2026)

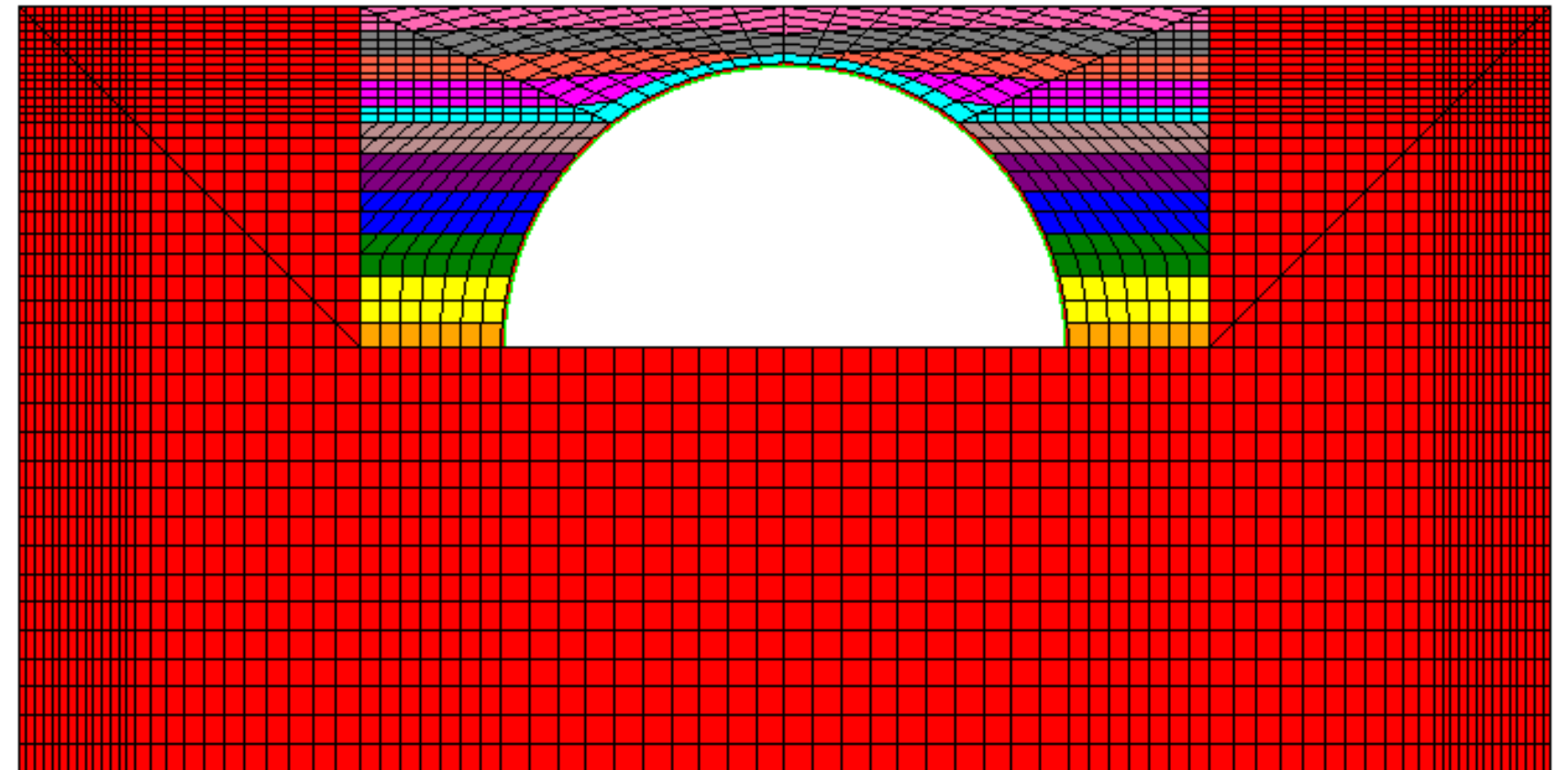
Where we are - Analysis

- Quad, Interface, and Tri elements are converted to BrDR C# elements
- Working on the Duncan/Duncan-Selig soil models
- Working on simple test suites under the guidance of Mike Katona
- Preliminary mesh generation work

Early stages—Phase I – Version 7.8 (2026)

Where we are - Analysis

- Preliminary mesh generation work



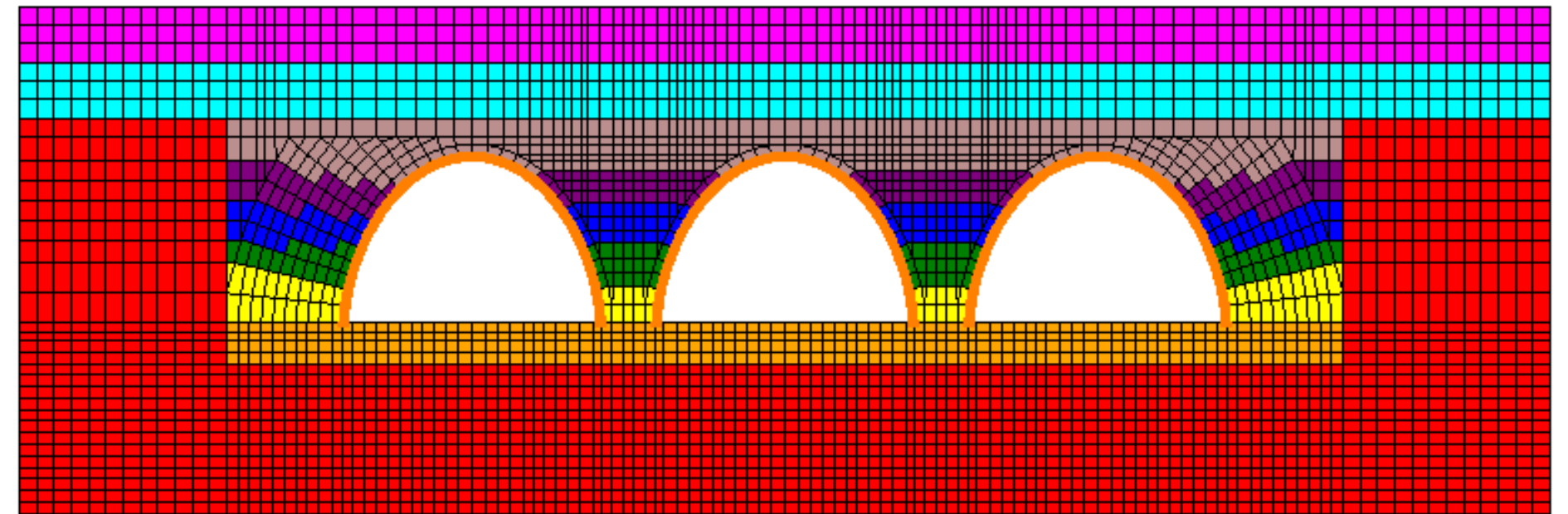
Early stages–Phase I – Version 7.8 (2026)

Where we are – Mockups for Phase 2 work

- Interface Mockups for RC Box (Phase 2.1)
- Interface Mockups for Corrugated Metal (Phase 2.2)
- Send to Culvert TAG for review

Phase III – Version 8.0+

- TAG and user driven
- Produce models for more complicated structures
- Multiple pipes
- Multiple materials
- Consider methods for improving the LL analysis





Thank you!

Questions?

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