AASHTOWare™ BRIDGE DESIGN AND RATING

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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AASHTOWare™ BRIDGE DESIGN AND RATING

Metal Culvert Ratings Demo

Metal Pipe Culvert and Metal Box Culvert

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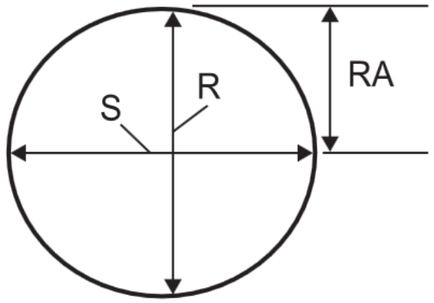
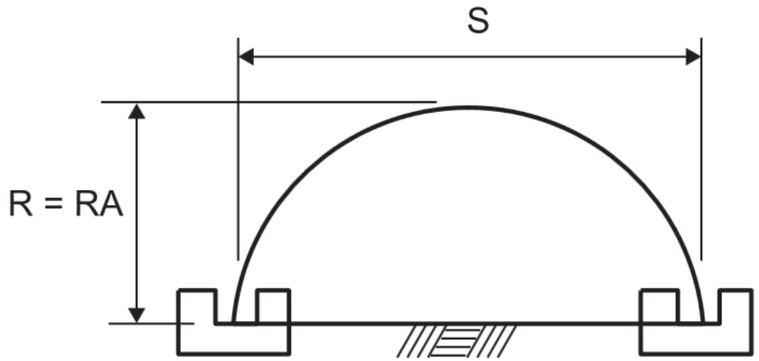
Metal Pipe Culvert Ratings

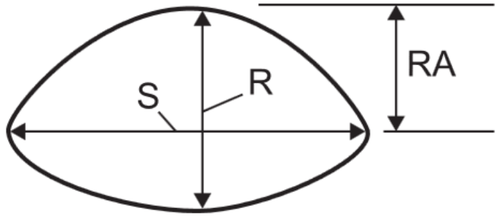
- Introduced with BrDR version 7.3.0.
- LFR and LRFR rating methods are supported.
- Rated for wall capacity and plastic moment capacity
- Aluminum and Steel material types.
- Single and multilane loading options.



Circular



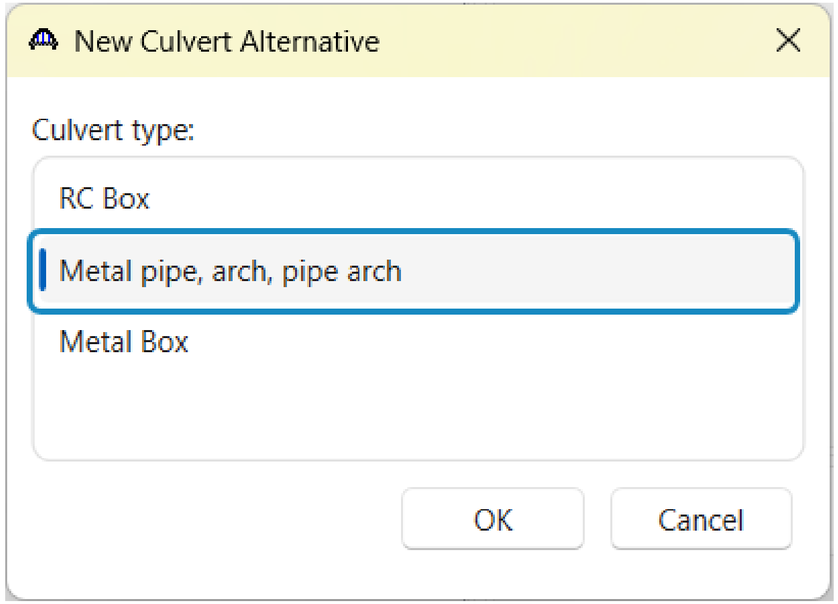
Arch

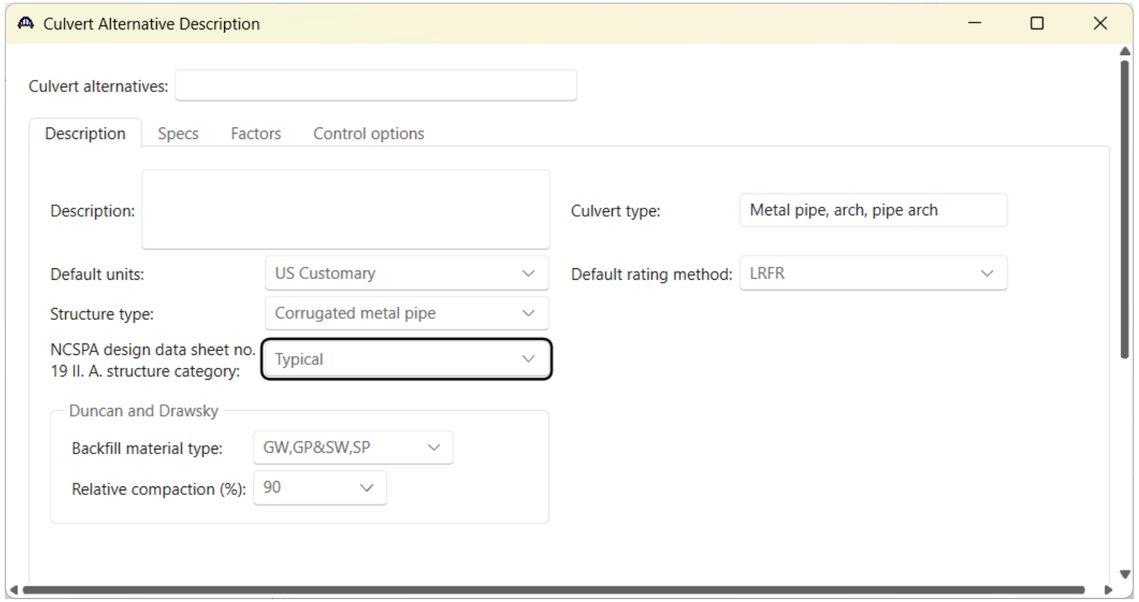


Pipe arch

Metal Pipe Culvert Ratings – Culvert Alternative

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



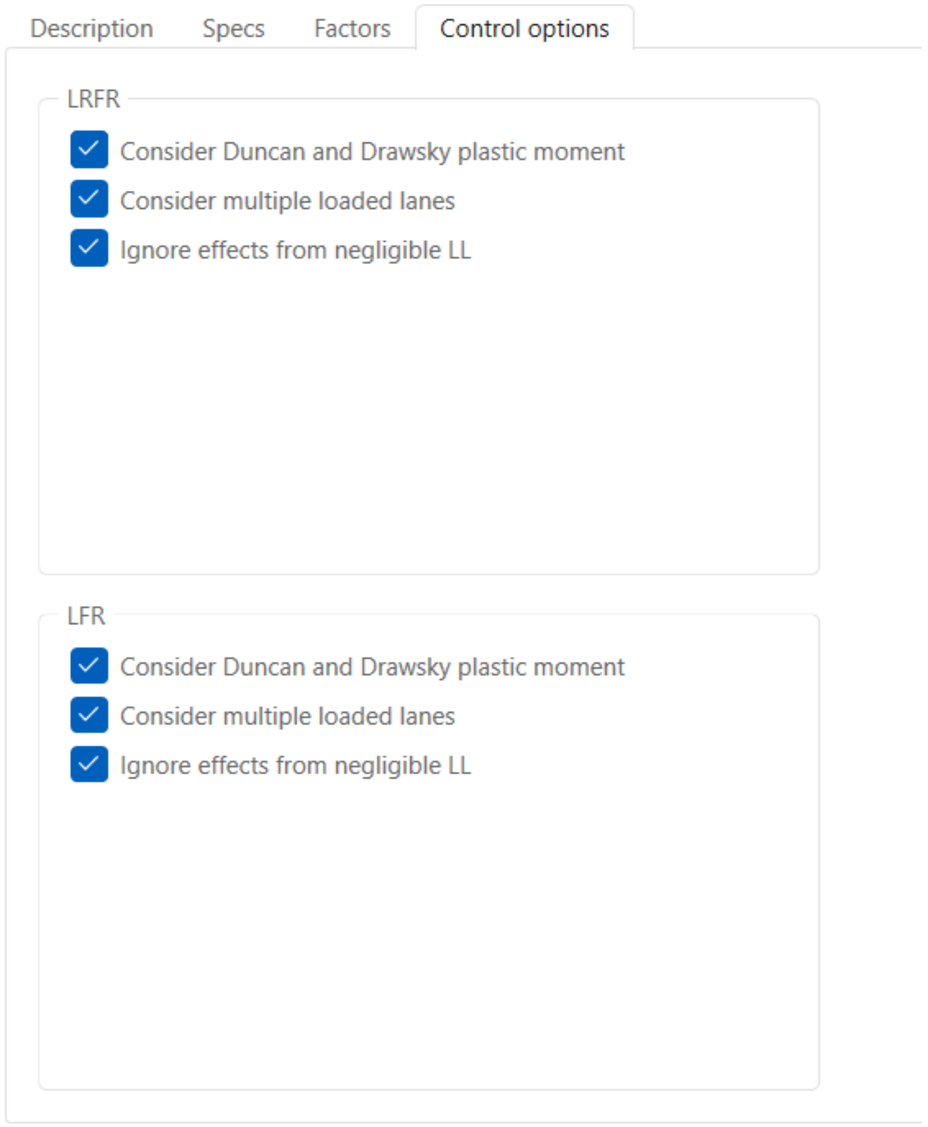


Metal Pipe Culvert Ratings – Control Options

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.



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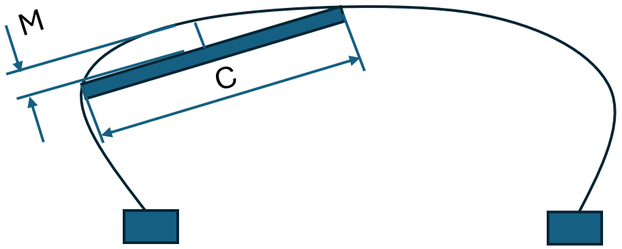
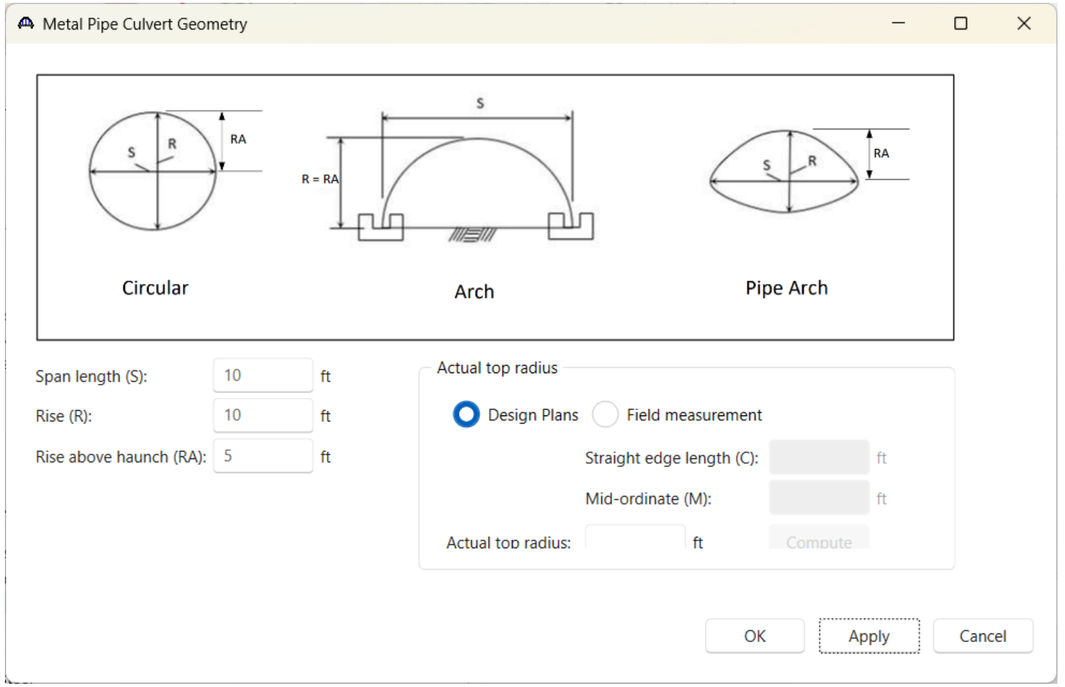
Metal Pipe Culvert Ratings – Metal Pipe Culvert Geometry

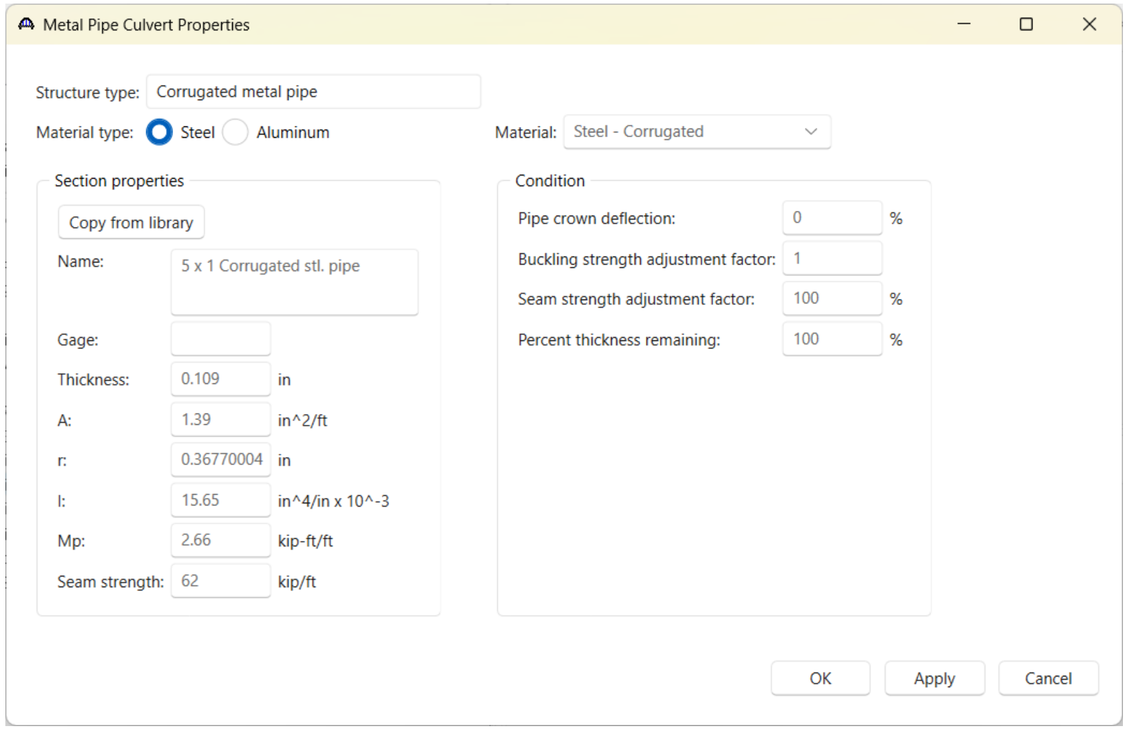
- Actual Top Radius input is required for “Long Span” or “Unsymmetrical or Deflect over 5%” structure categories.
- Field measurement calculation:



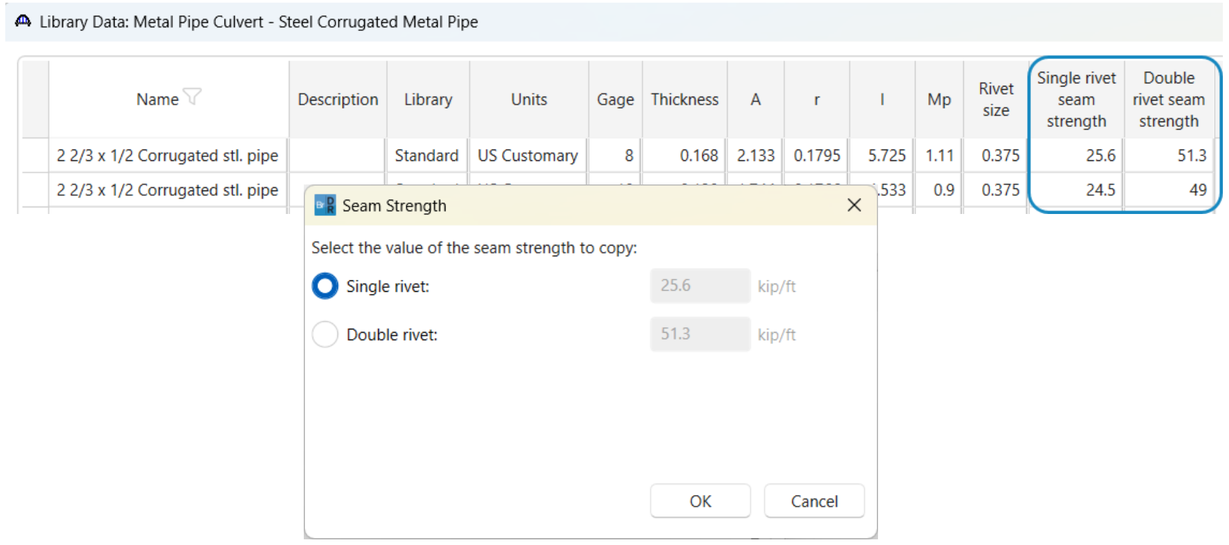
$$R = \frac{M}{2} + \frac{C^2}{8M}$$



Metal Pipe Culvert 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.



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Metal Pipe Culvert Ratings – Metal Pipe Culvert Loads

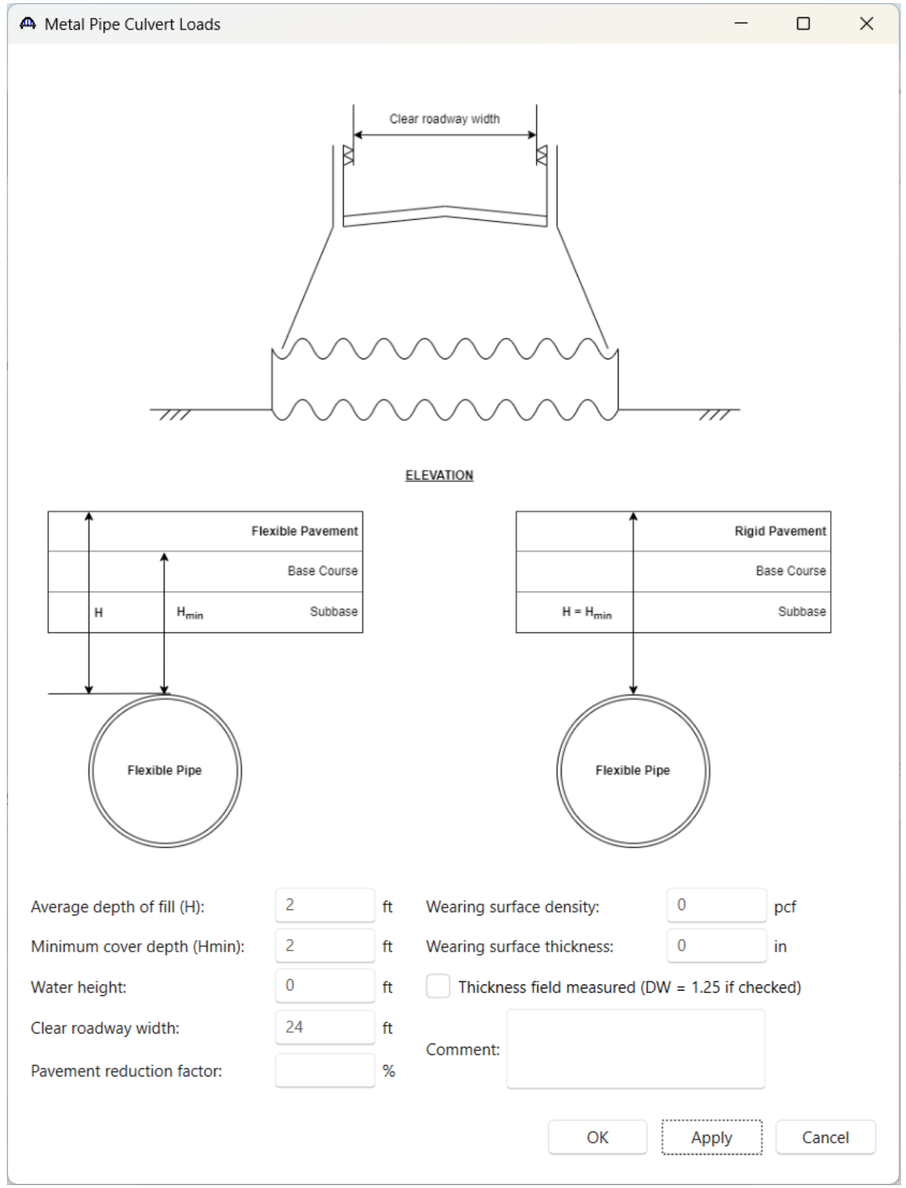
Average Depth of Fill (H): Enter depth of fill including any wearing surface. Used for dead load calculations.

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.



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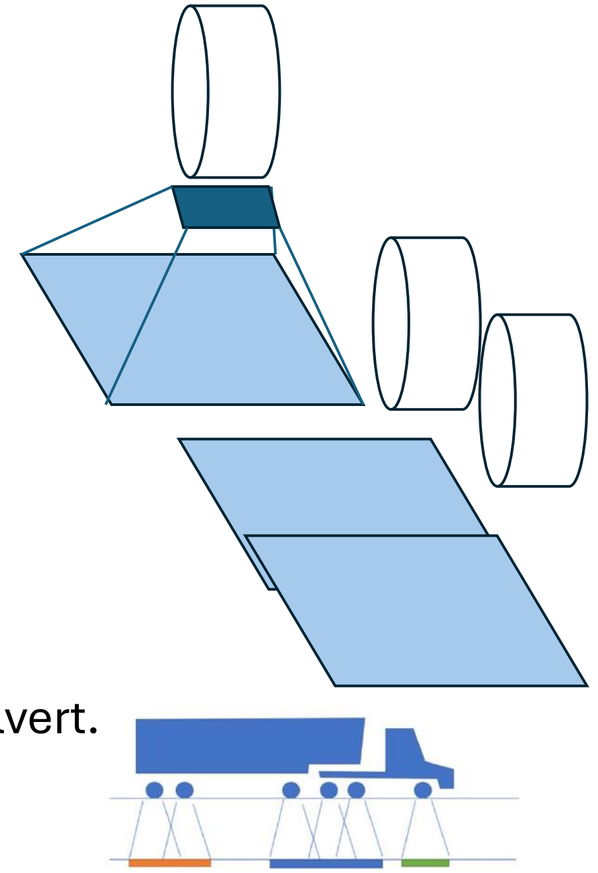
Metal Pipe Culvert Ratings – Live Load Thrust Calculation

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 (kip)	Axle Spacing (ft)	Pressure (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 (kip)	Axle Spacing (ft)	wt (ft)	sw (ft)	Ww (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)


                                          P * (1 + IM / 100) * MPF
Live Load Vertical Crown Pressure (Pl) = --------------------------       (3.6.1.2.6b-7)
                                                  A_LL
```

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

Metal Pipe Culvert Ratings – Results

Specification Check Detail

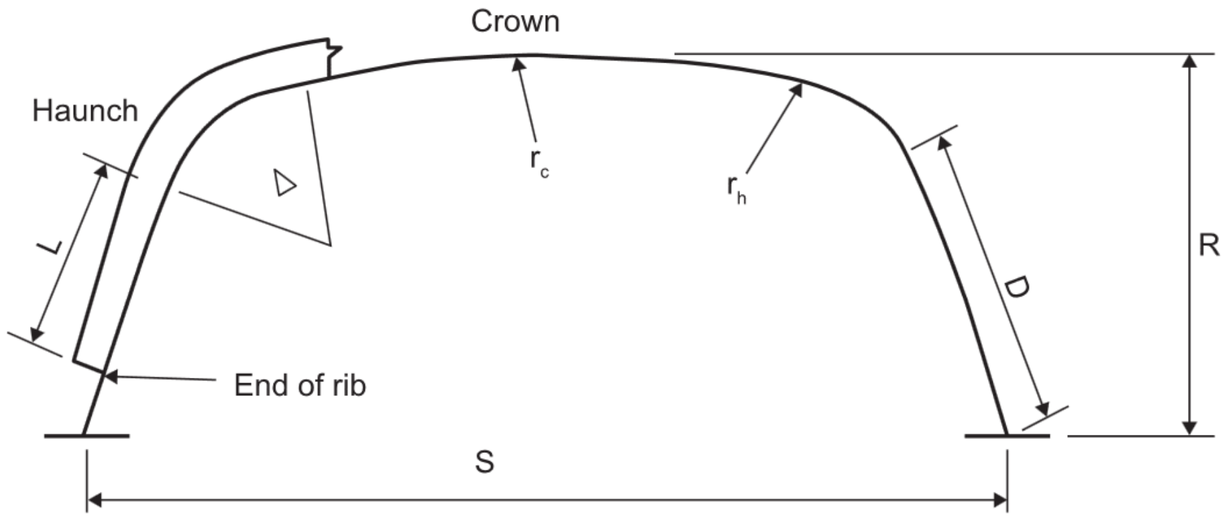
Specification reference	Limit State	Flex. Sense	Pass/Fail
12.7.2 Safety Against Structural Failure		N/A	General Comp.
12.7.2.2.DL Dead Load Thrust		N/A	General Comp.
12.7.2.2.LL Live Load Thrust		N/A	General Comp.
12.7.2.4 Resistance to Buckling		N/A	General Comp.
3.6.2.2 Culvert Dynamic Load Allowance		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.



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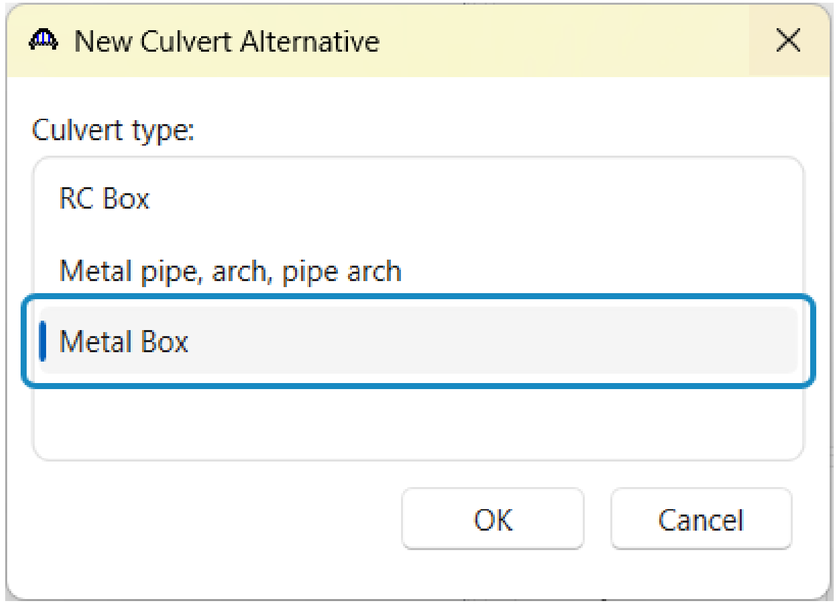
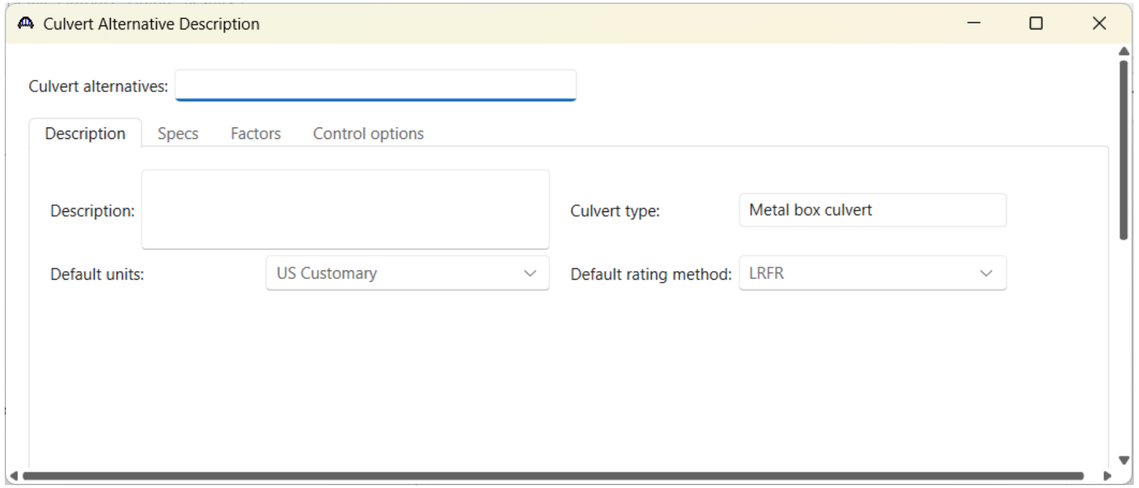
Metal Box Culvert Ratings – Culvert Alternative

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





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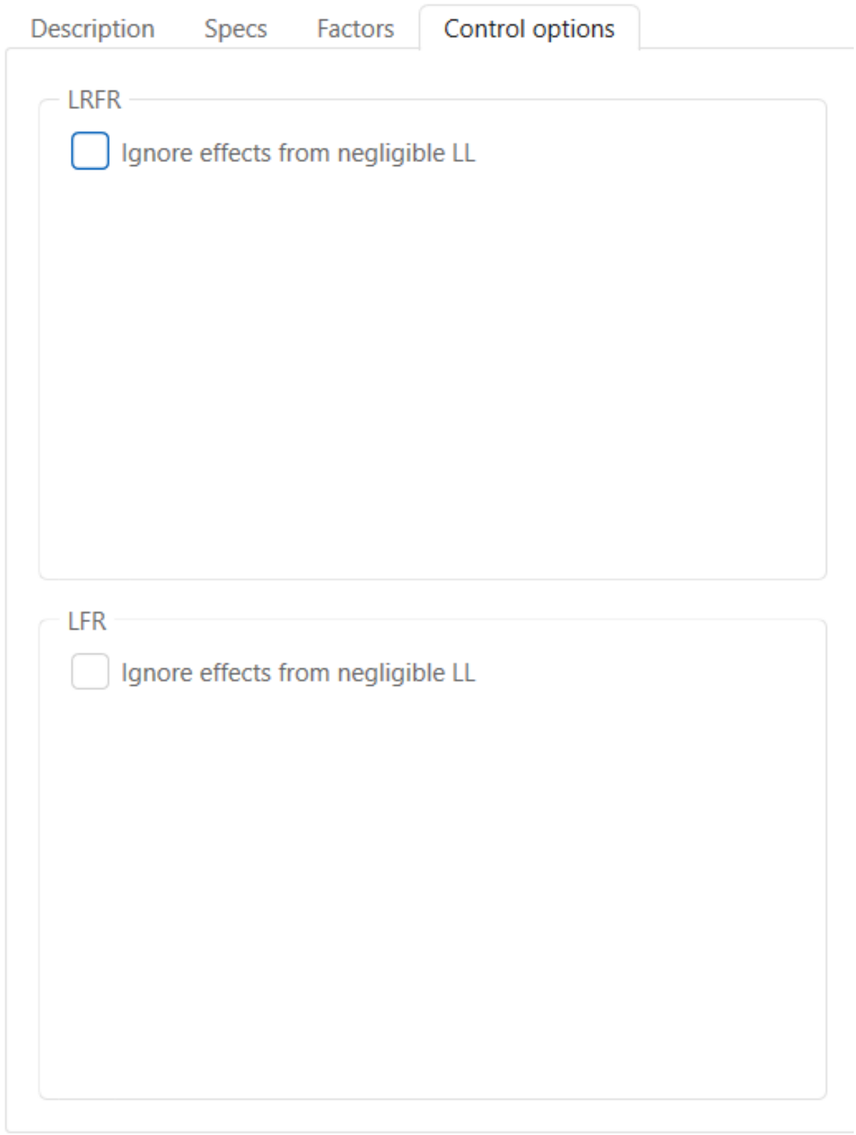
Metal Box Culvert Ratings – Control Options

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.



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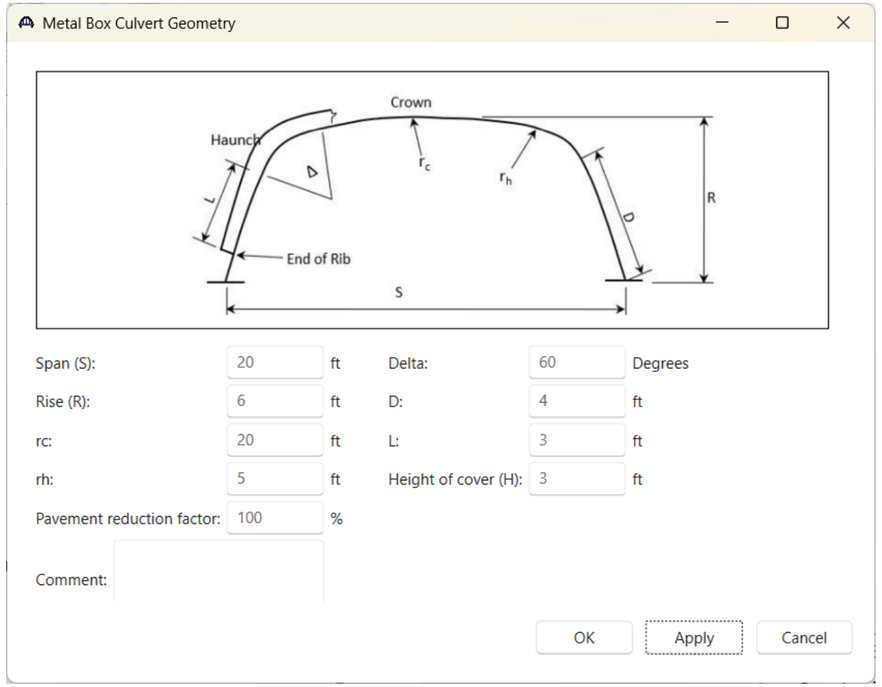
Metal Box Culvert Ratings – Metal Box Culvert Geometry

- 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.



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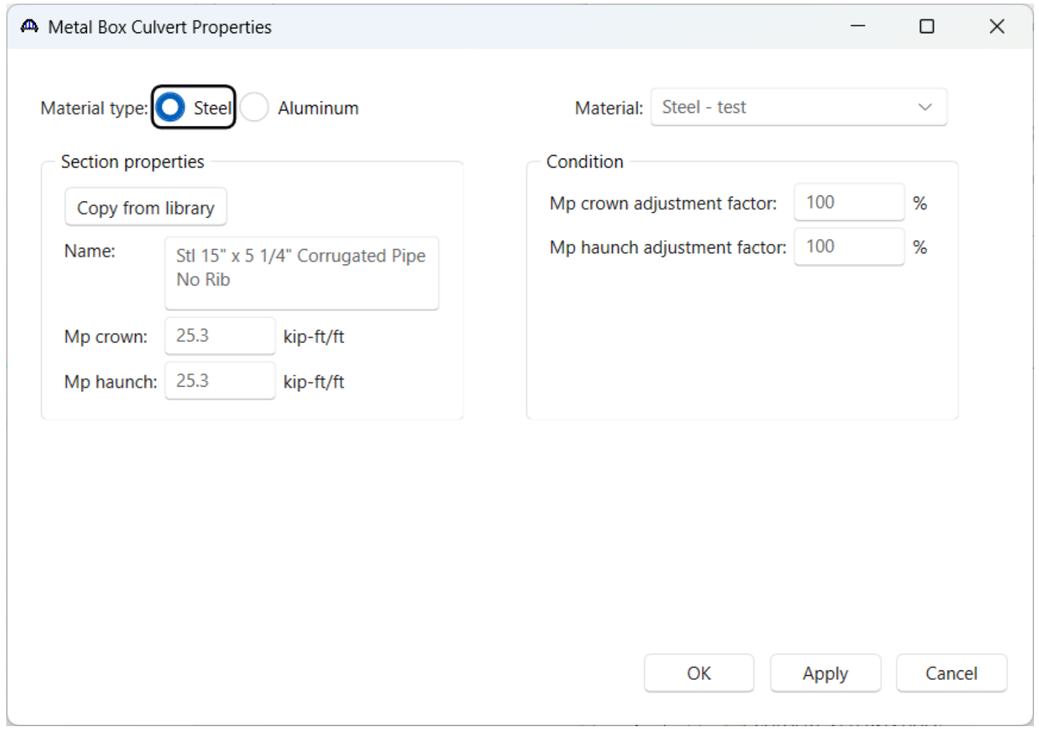
Metal Box Culvert Ratings – Metal Box Culvert Properties



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

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SSI Implementation Update

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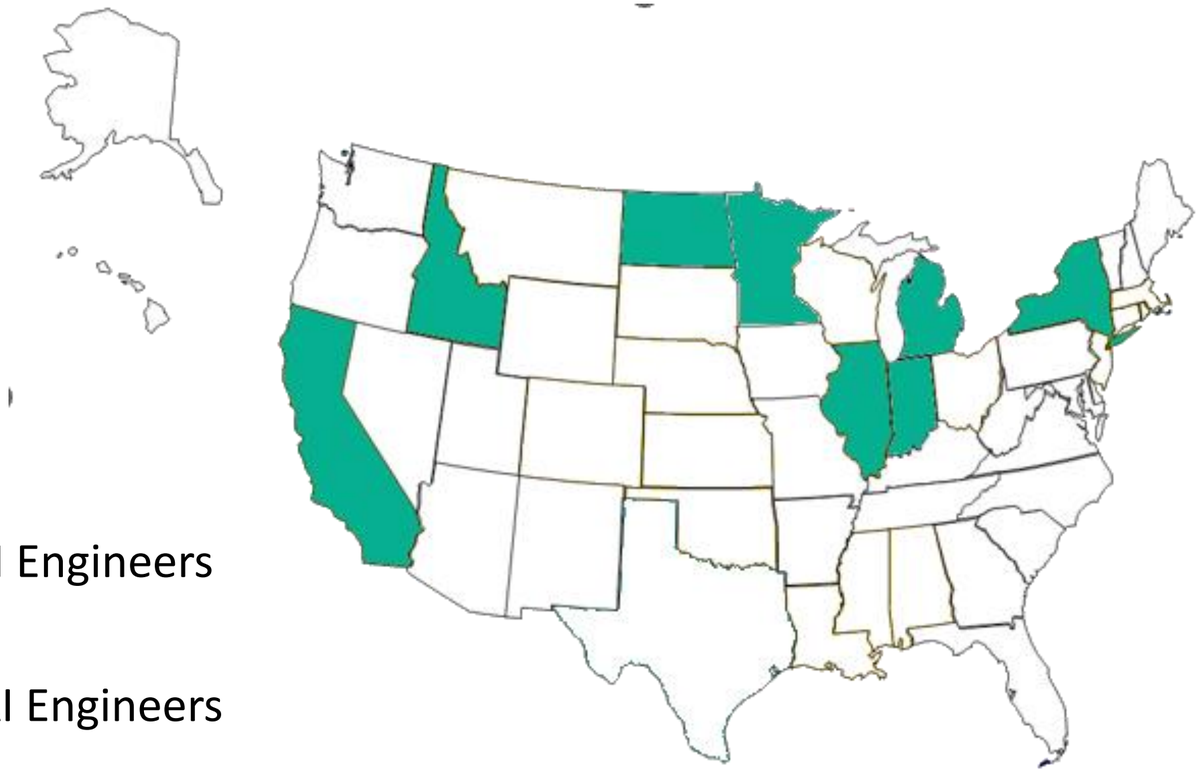
SSI Implementation Update

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



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Early stages–Phase I – Version 7.8 (2026)

- Developing Elements similar to CANDE
- Using modern programming techniques and practices

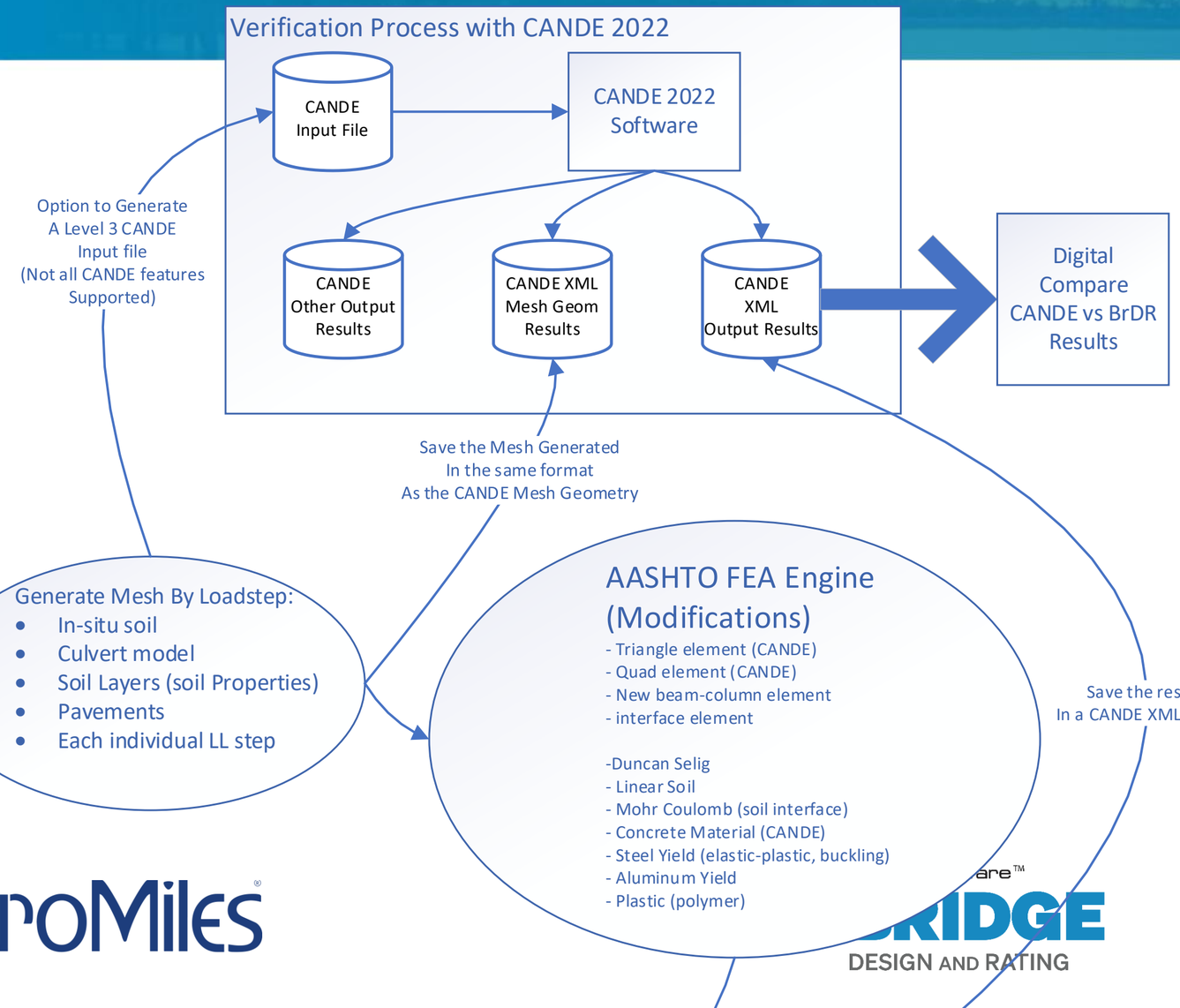
  (NOT integrating the existing CANDE into BrDR – just the techniques)
- Creating the analysis engine to run Level 3 models

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



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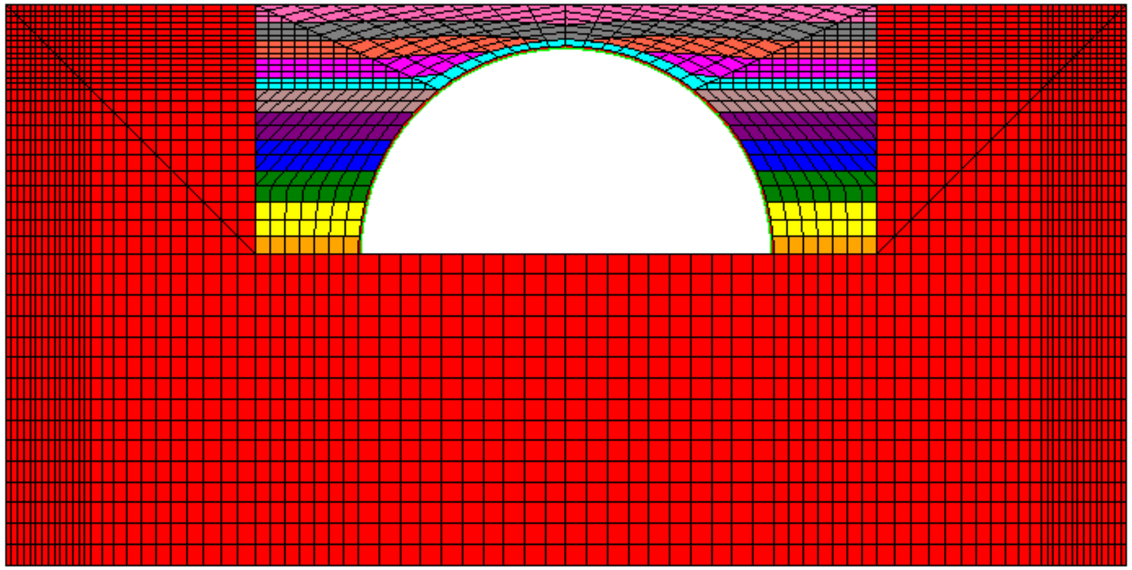
Where we are - Analysis

- 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

Where we are - Analysis

- Preliminary mesh generation work

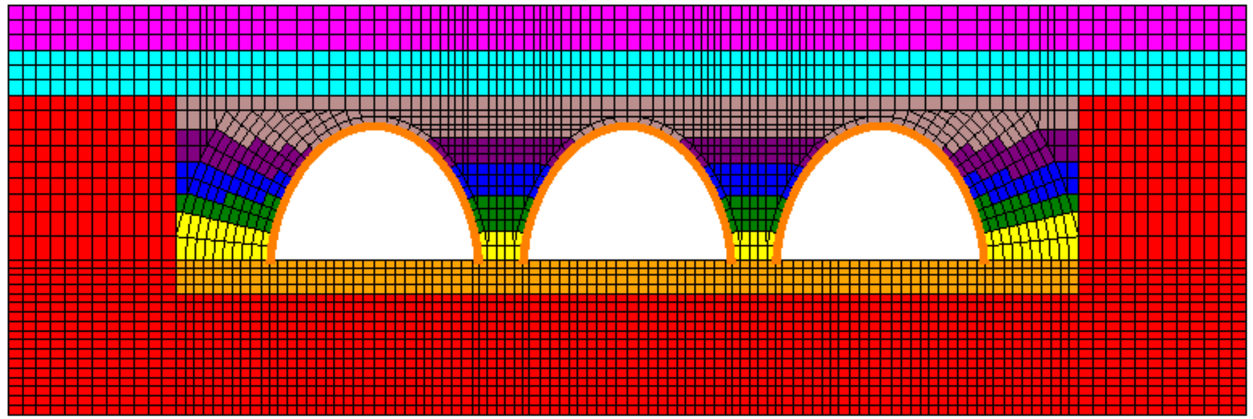


Where we are – Mockups for Phase 2 work

- 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



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Thank you!

Questions?

2025 Rating and Design Bridge User Group Meeting

Boise, ID | August 12-13, 2025

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