



OHIO DEPARTMENT OF TRANSPORTATION

MIKE DEWINE, GOVERNOR

JACK MARCHBANKS, DIRECTOR

Metal Culvert Rating



Amjad Waheed, PE
OHDOT

RADBUG 2023, Madison WI

2023

Referenced Specifications

1. ASHTO Standard Specifications for Highway Bridges-Division 1, Section 12
2. AASHTO LRFD Bridge Design Specifications – Section 12
3. ASTM Standard Practice for Structural Design of Corrugated Steel Pipe, Pipe Arches, and Arches for Storm and Sanitary Sewers and Other Buried Applications – ASTM A796
4. AREMA Manual for Railway Engineering – Section 4.9



On-line Resources

- www.transportation.org
- www.astm.org
- www.NCSPA.org
 - NCSPA Corrugated Steel Pipe Design Manual
 - Design Data Sheet #19 – “Load Rating and Structural Evaluation of In-Service, Corrugated Steel Structures”



On-line Resources

CORRUGATED STEEL PIPE Design Manual

NCSPA DESIGN DATA SHEET No. 19

LOAD RATING AND STRUCTURAL EVALUATION OF
IN-SERVICE, CORRUGATED STEEL STRUCTURES

LOAD RATING AND STRUCTURAL EVALUATION OF IN-SERVICE, CORRUGATED STEEL STRUCTURES

Load rating, and other structural evaluations of in-service corrugated steel structures, is a two-step process. As with any major structure, both a complete field evaluation of the structure's condition, as well as an analytical evaluation of that structure's load carrying capabilities are required. The analytical evaluation is based on the structure's actual in-service shape and condition, as well as actual field and design loading needs.

• The FHWA CULVERT INSPECTION MANUAL (Ref. 1)

- d. Mid-ordinate of each radius arc segment (for multi radius structure shapes)
2. Unsymmetrical Structures, structures deflected more than 5% from design shape, or those that show localized distortions require that the actual maximum radius be determined in those distorted areas as shown in Appendix B.2. *Use two times the actual maximum radius rather than the span in structural design checks. Typically this*

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NCSPA

National Corrugated Steel Pipe Association



CMP (Corrugated Metal Pipe)



Metal Culvert Rating in BrR 7.4.1

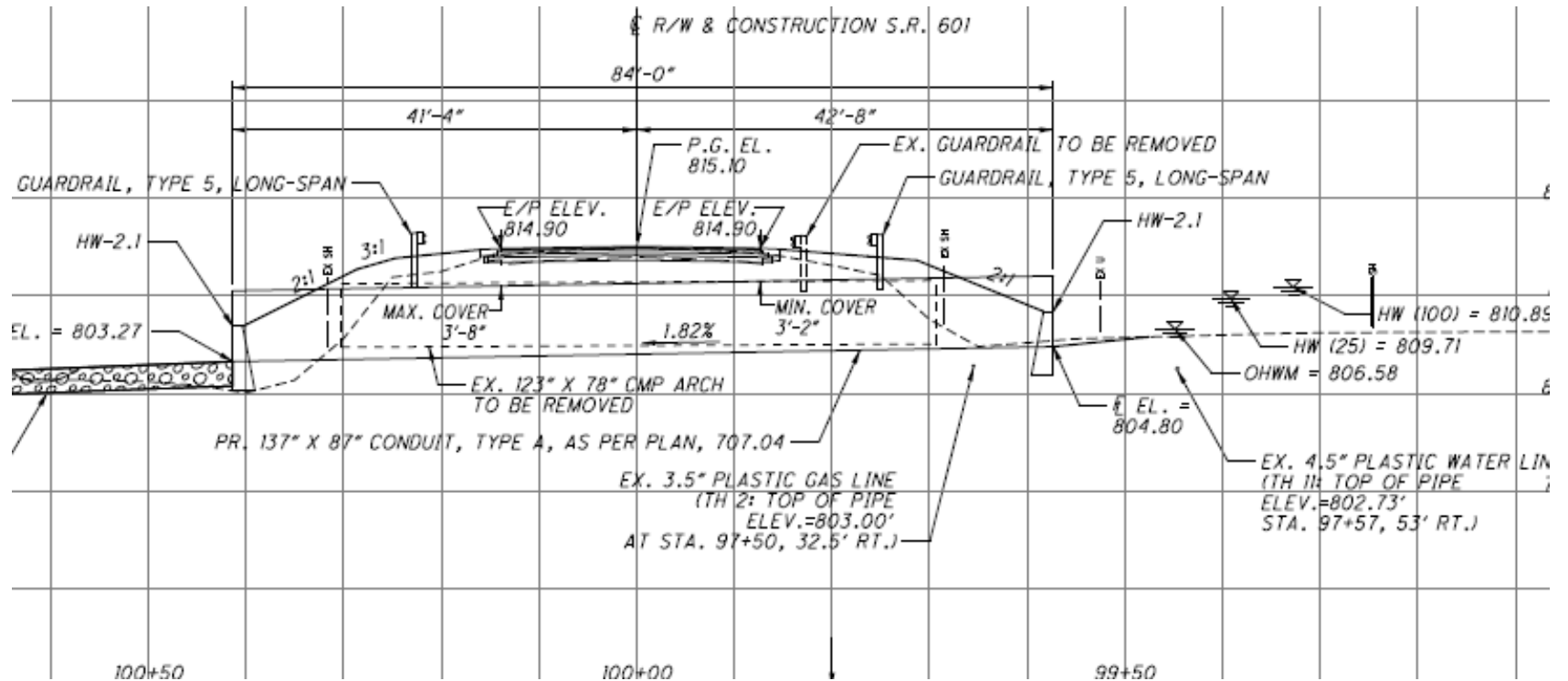


Metal Box Culvert

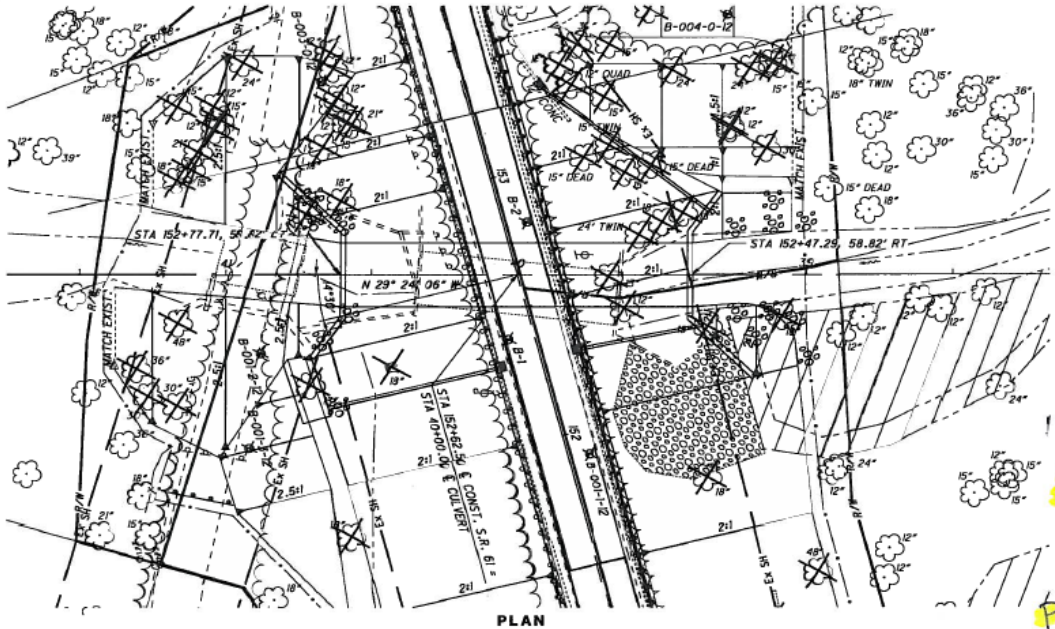


Metal Culvert Rating in BrR 7.4.1

Example of a CMP



Metal Culvert Rating in BrR 7.4.1



BENCHMARK DATA	
BENCHMARK NO. 4:	
BERNSTEIN MARKER LABELED SURVEY CONTROL STA. 151+05.31, 166.41' LT.	ELEV. 708.42

BENCHMARK DATA	
BENCHMARK NO. 10:	
BERNSTEIN MARKER LABELED SURVEY CONTROL STA. 152+75.55, 87.68' LT.	ELEV. 705.70

LEGEND
 ⊕ BORING LOCATION
 Ⓢ ROCK CHANNEL PROTECTION

HYDRAULIC DATA
 DRAINAGE AREA = 7.58 SQUARE MILES
 Q (25) = 1370 CFS V (25) = 9.70 FT/S
 Q (100) = 1840 CFS V (100) = 11.32 FT/S

BORING	STATION	OFFSET	TOP OF GROUND ELEVATION
B-001-1-12	151+91	7.5 RT.	719.4
B-001-2-12	152+56	92.6 LT.	704.8
B-001-3-12	152+22	105.2 LT.	702.9
B-003-0-12	153+50	47.1 LT.	710.1
B-004-0-12	153+39	95.2 RT.	732.4
B-1	152+36	9.1 LT.	720.3
B-2	152+78	8.1 RT.	720.2

EXISTING STRUCTURE	
TYPE:	STONE BLOCK SPANDREL ARCH
SPAN:	+20'-0"
ROADWAY:	+31'-0" F/F RAIL
LOADING:	UNKNOWN
SKEW:	21°-0% L.F.
APPROACH SLABS:	NONE
ALIGNMENT:	TANGENT
CROWN:	0.016%
STRUCTURAL FILE NUMBER:	3902102
DATE BUILT:	1930

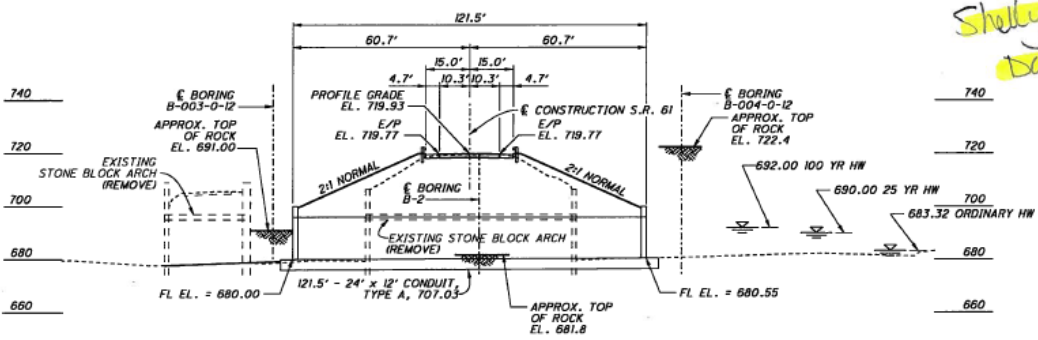
PROPOSED STRUCTURE	
TYPE:	STRUCTURAL STEEL PLATE ARCH ON REINFORCED CONCRETE SPREAD FOOTING
SPAN:	24'-0"
ROADWAY:	28'-0" F/F RAIL
LOADING:	HL-93
SKEW:	14°30'00" L.F.
APPROACH SLABS:	NONE
ALIGNMENT:	TANGENT
CROWN:	0.016 FT/FT
COORDINATES:	LATITUDE N41°16'13" LONGITUDE W82°34'16"

3902102

Proj. 377-13

Shelly/Sando

Donofrio



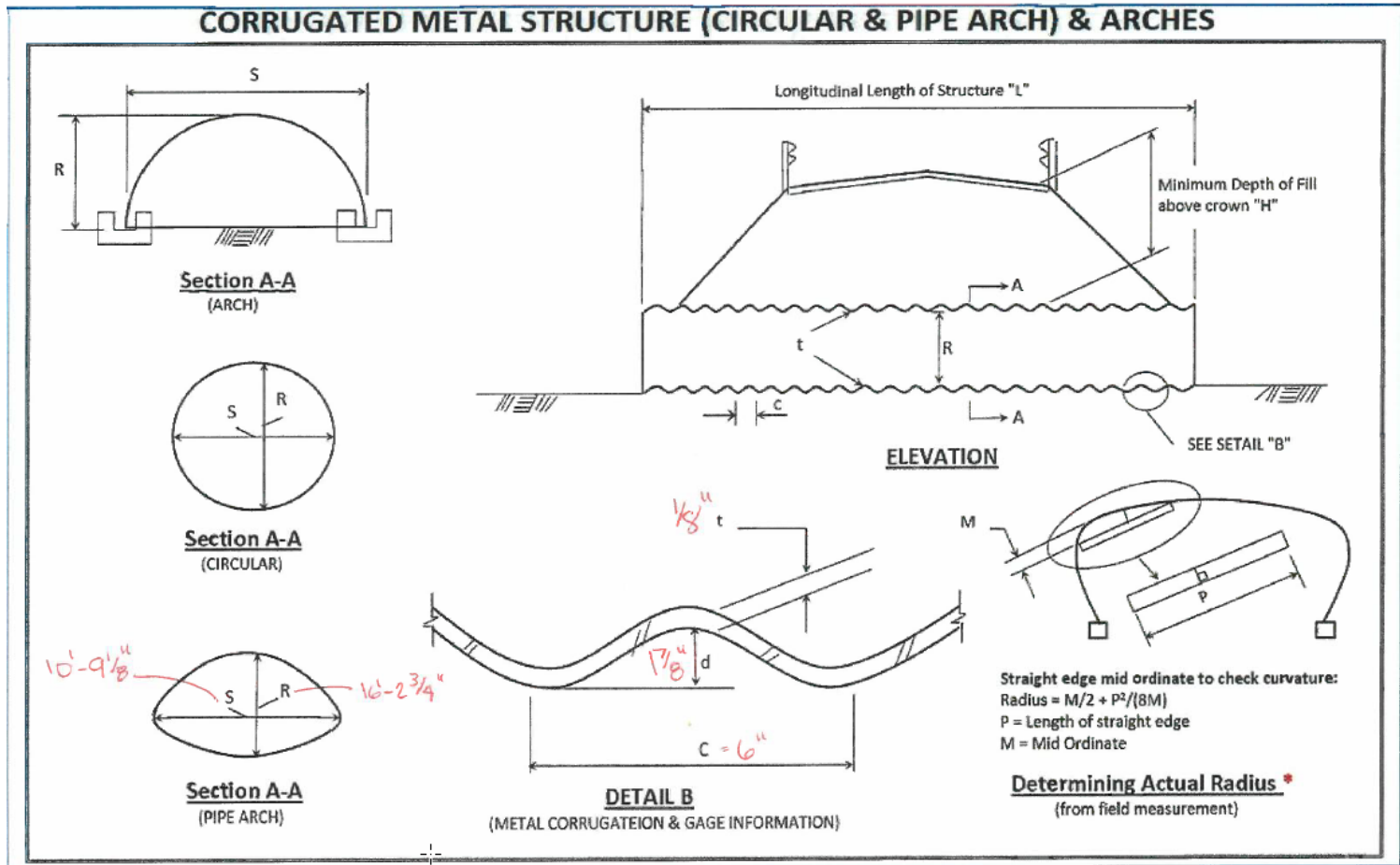
PROFILE ALONG CENTERLINE CULVERT



Metal Culvert Rating in BrR 7.4.1

Example of field measurements

DEF-7-0349 SFN 4160131



Metal Culvert Rating in BrR 7.4.1

Example of field measurements

Wang, Cindy

From: Wisse, Geoffry
Sent: Tuesday, October 5, 2021 2:32 PM
To: Wang, Cindy; Waheed, Amjad
Cc: Eilerman, Lee
Subject: RE: Load Rating

Follow Up Flag: Follow up
Flag Status: Flagged

Cindy,
Span = 9.5'. 27 degree skew = 10.7' along center line
Rise = 6.5'
Metal Corrugation = C= 6", d= 2"
Gauge/thickness = 0.158"
Depth of fill = 4'
Radius = I don't know.

Geoff Wisse

From: Wang, Cindy <Cindy.Wang@dot.ohio.gov>
Sent: Tuesday, October 5, 2021 10:11 AM
To: Waheed, Amjad <Amjad.Waheed@dot.ohio.gov>; Wisse, Geoffry <Geoff.Wisse@dot.ohio.gov>
Subject: RE: Load Rating

Geoff,
I need little more information regarding the load rating of this CMP. Can you send someone to the field and do some measurements? I need the span, rise, radius and metal corrugation, gage information, and depth of fill information.



Metal Culvert Rating in BrR 7.4.1



Metal Culvert Rating in BrR 7.4.1



Load Rating of CMP

Load Factor Rating Basic AASHTO Equation

Operating rating factor

$$RF_o = \frac{S}{1.3} - \beta * D / (L + I)$$

S = Strength

D = Dead load effect

L = Live Load effect

I = Dynamic effect

β = Dead load factor

$$\text{Inventory rating factor (RF}_i\text{)} = \frac{3}{5} * RF_o$$



Metal Culvert Example 1

BrR 7.4.1



Metal Culvert Rating in BrR 7.4.1

MetalCulvertExample1



Bridge ID: NBI structure ID (8):

Template Superstructures
 Bridge completely defined Culverts
 Substructures

- Description
- Description (cont'd)
- Alternatives
- Global reference point
- Traffic
- Custom agency fields

Name:

Description:

Location:

Facility carried (7):

Feat. intersected (6):

Default units:



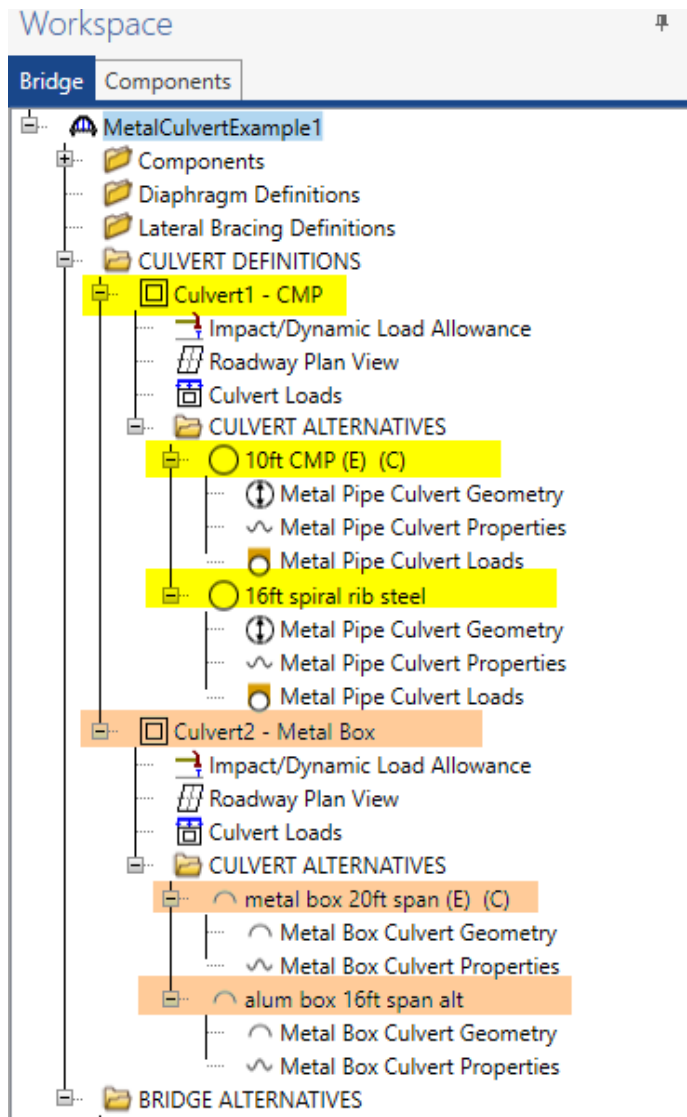
Workspace

Bridge Components

- MetalCulvertExample1
 - Components
 - Diaphragm Definitions
 - Lateral Bracing Definitions
 - CULVERT DEFINITIONS**
 - Culvert1 - CMP
 - Culvert2 - Metal Box
 - BRIDGE ALTERNATIVES
 - culvert1 (E) (C)



Metal Culvert Rating in BrR 7.4.1



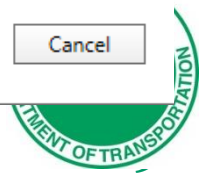
Metal Culvert Rating in BrR 7.4.1

Components

The screenshot shows a software interface with a materials library on the left and a dialog box titled "Bridge Materials - Aluminum" on the right. The library tree includes folders for LRFR, LRFD Substructure Design Settings, and Materials. Under Materials, there is an "Aluminum" folder containing "Structural Plate 0.176-0.250" and "Structural Plate test". The dialog box has the following fields:

- Name:
- Description:
- Material properties:
 - Specified minimum yield strength (Fy): ksi
 - Specified minimum tensile strength (Fu): ksi
 - Coefficient of thermal expansion: 1/F
 - Density: kcf
 - Modulus of elasticity (E): ksi

At the bottom of the dialog box, there are five buttons: "Copy to library...", "Copy from library..." (highlighted with a red box), "OK", "Apply", and "Cancel". A red arrow points from the "Structural Plate 0.176-0.250" item in the library to the "Name" field in the dialog box.



Metal Culvert Rating in BrR 7.4.1

MetalCulvertExample1

- Components
- Diaphragm Definitions
- Lateral Bracing Definitions
- MPF LRFD Multiple Presence Factors
- EC Environmental Conditions
- DP Design Parameters
- SUPERSTRUCTURE DEFINITIONS
- CULVERT DEFINITIONS
 - Culvert1 - CMP
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
 - CULVERT ALTERNATIVES
 - 10ft CMP (E) (C)
 - 16ft spiral rib steel
 - Culvert2 - Metal Box
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads

Soil material: Standard Soil 1

Water unit load: 62.4 pcf

Culvert Definition Impact/Dyn...

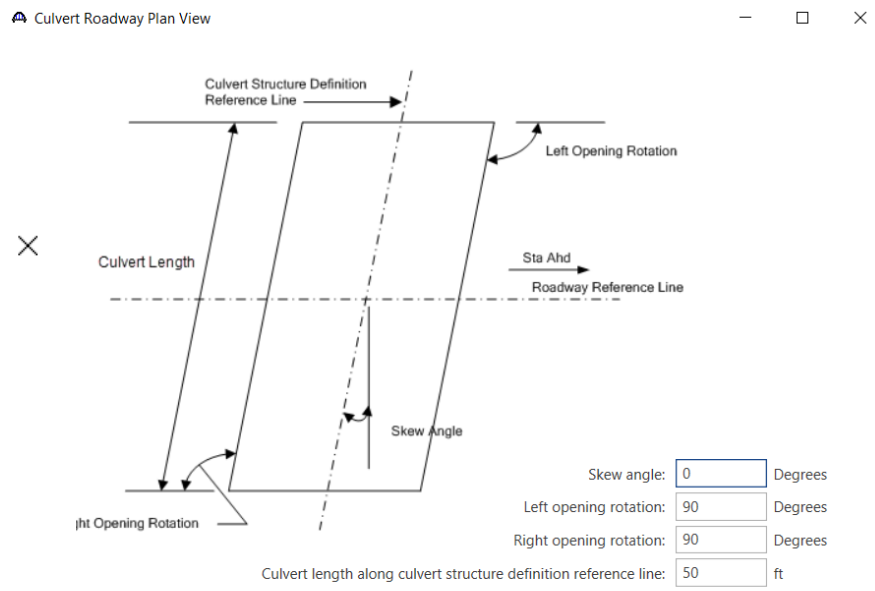
Standard impact factor

Standard AASHTO Impact

LRFD dynamic load allowance

AASHTO DLA IM=33(1.0-0.125DE)>=0%

OK Apply Cancel



Skew angle: 0 Degrees

Left opening rotation: 90 Degrees

Right opening rotation: 90 Degrees

Culvert length along culvert structure definition reference line: 50 ft

OK Apply Cancel

OK Apply Cancel



Metal Culvert Rating in BrR 7.4.1

- Lateral bracing Definitions
- CULVERT DEFINITIONS
 - Culvert1 - CMP
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
 - CULVERT ALTERNATIVES
 - 10ft CMP (E) (C)
 - Metal Pipe Culvert Geometry** →
 - Metal Pipe Culvert Properties
 - Metal Pipe Culvert Loads
 - 16ft spiral rib steel
 - Metal Pipe Culvert Geometry
 - Metal Pipe Culvert Properties
 - Metal Pipe Culvert Loads
 - Culvert2 - Metal Box
- BRIDGE ALTERNATIVES

Metal Pipe Culvert Geometry

Circular Arch Pipe Arch

Span length (S): ft
Rise (R): ft
Rise above haunch (RA): ft

Actual top radius

Design Plans Field measurement

Straight edge length (C): ft
Mid-ordinate (M): ft
Actual top radius: ft



Metal Culvert Rating in BrR 7.4.1

Field measurements

Check this option to enter field measurement values. Checking this box enables the options below and the compute button:

Straight edge length (C)

Enter the straight edge length for the metal pipe culvert.

Mid-ordinate (M)

Enter the Mid-ordinate value for the metal pipe culvert.

Actual top radius

Enter the top radius of the metal pipe culvert or use the Compute button to calculate the actual top radius based on the formula shown below. This value is required if the structure category type is Long Span, Unsymmetrical or Deflect over 5%. This value must be entered.

Compute

Computes the actual top radius of the metal pipe culvert based on the following equation:

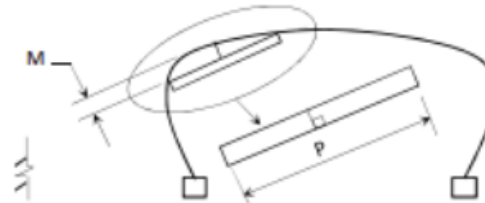
$$R = \frac{M}{2} + \frac{C^2}{8M}$$

Where,

R = actual top radius

M = Mid-ordinate

C = Straight edge length (C)



Straight edge mid ordinate to check curvature:

$$\text{Radius} = M/2 + P^2/(8M)$$

P = Length of straight edge

M = Mid Ordinate

Determining Actual Radius

(from field measurement)

Metal Culvert Rating in BrR 7.4.1

Structure type: Corrugated metal pipe

Material type: Steel Aluminum

Material: Steel - Corrugated

Section properties

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 %

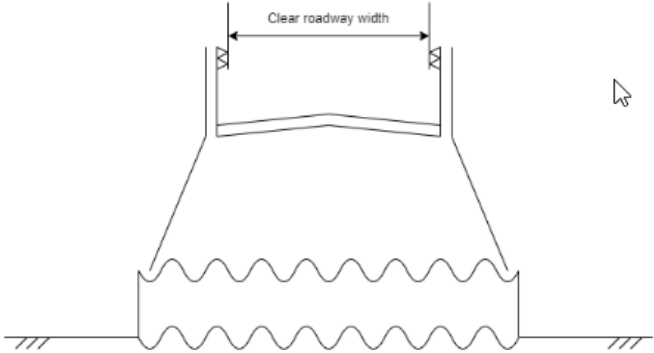
Percent thickness remaining: 100 %



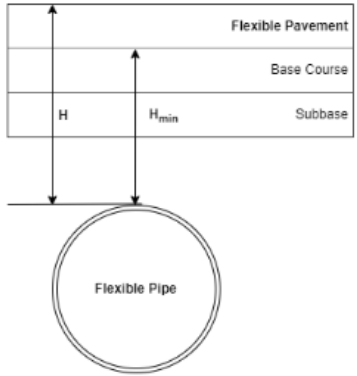
Metal Culvert Rating in BrR 7.4.1

Metal Pipe Culvert Loads

- Lateral bracing Definitions
- CULVERT DEFINITIONS
 - Culvert1 - CMP
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
 - CULVERT ALTERNATIVES
 - 10ft CMP (E) (C)
 - Metal Pipe Culvert Geometry
 - Metal Pipe Culvert Properties
 - Metal Pipe Culvert Loads
 - 16ft spiral rib steel
 - Metal Pipe Culvert Geometry
 - Metal Pipe Culvert Properties
 - Metal Pipe Culvert Loads
- Culvert2 - Metal Box
- BRIDGE ALTERNATIVES



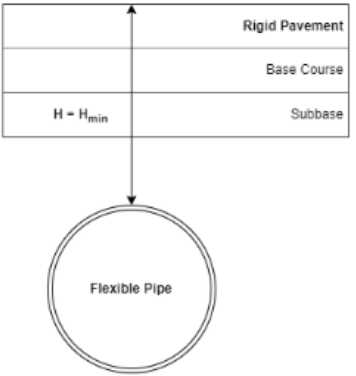
ELEVATION



Flexible Pavement
Base Course
Subbase

H
H_{min}

Flexible Pipe



Rigid Pavement
Base Course
Subbase

H = H_{min}

Flexible Pipe

Average depth of fill (H): ft Wearing surface density: pcf

Minimum cover depth (Hmin): ft Wearing surface thickness: in

Water height: ft Thickness field measured (DW = 1.25 if checked)

Clear roadway width: ft

Pavement reduction factor: %

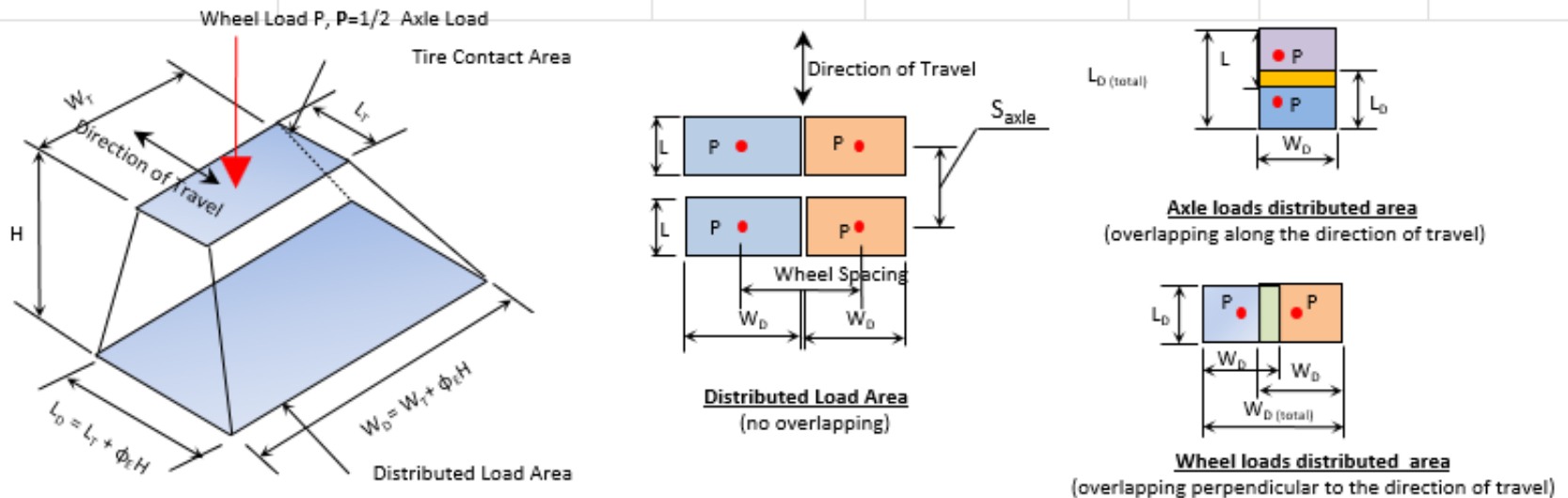
Comment:

OK Apply Cancel



Load Rating of CMP

Wheel Load distribution through fill



Where, W_T = Tire contact width, L_T = Tire contact length, W_D = Distributed load width, L_D = Distributed load length



Metal Culvert Rating in BrR 7.4.1

CULVERT DEFINITIONS

- Culvert1 - CMP
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
- CULVERT ALTERNATIVES**
 - 10ft CMP (E) (C)
 - Metal Pipe Culvert Geometry
 - Metal Pipe Culvert Properties
 - Metal Pipe Culvert Loads
 - 16ft spiral rib steel**
 - Metal Pipe Culvert Geometry
 - Metal Pipe Culvert Properties
 - Metal Pipe Culvert Loads
- Culvert2 - Metal Box

Metal Pipe Culvert Geometry

Input Fields:

Span length (S): ft

Rise (R): ft

Rise above haunch (RA): ft

Actual top radius:

Design Plans Field measurement

Straight edge length (C): ft

Mid-ordinate (M): ft

Actual top radius: ft



Metal Culvert Rating in BrR 7.4.1

The image shows a software interface for defining culvert properties. On the left is a tree view under 'CULVERT DEFINITIONS'. The '16ft spiral rib steel' option is selected. A red arrow points from this option to the 'Metal Pipe Culvert Properties' dialog box. The dialog box has the following fields:

- Structure type: Spiral rib metal pipe
- Material type: Steel Aluminum
- Material: Steel - Corrugated
- Section properties:
 - Copy from library
 - Name: 3/4 x 1 x 11 1/2 Spiral rib stl. pipe
 - Gage: []
 - Thickness: 0.109 in
 - A: 0.883 in²/ft
 - r: 0.355 in
 - I: 9260 in⁴/in x 10⁻³
 - Mp: [] kip-ft/ft
 - Seam strength: [] kip/ft
- Condition:
 - Pipe crown deflection: [] %
 - Buckling strength adjustment factor: []
 - Seam strength adjustment factor: [] %
 - Percent thickness remaining: [] %

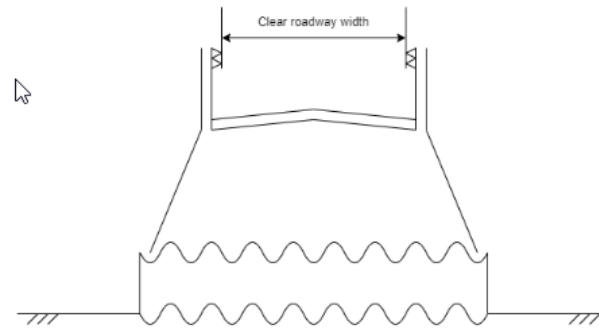
Buttons at the bottom: OK, Apply, Cancel.



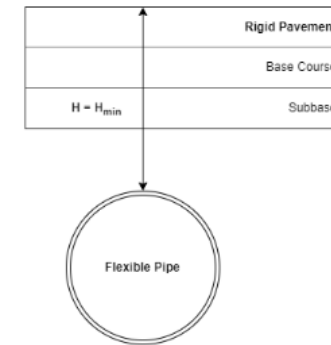
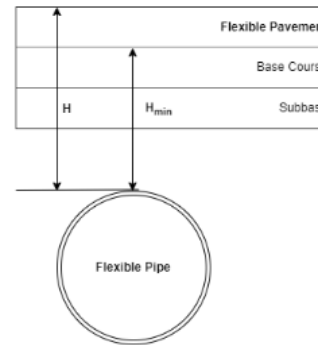
Metal Culvert Rating in BrR 7.4.1

Metal Pipe Culvert Loads

- CULVERT DEFINITIONS
 - Culvert1 - CMP
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
 - CULVERT ALTERNATIVES
 - 10ft CMP (E) (C)
 - Metal Pipe Culvert Geometry
 - Metal Pipe Culvert Properties
 - Metal Pipe Culvert Loads
 - 16ft spiral rib steel
 - Metal Pipe Culvert Geometry
 - Metal Pipe Culvert Properties
 - Metal Pipe Culvert Loads
 - Culvert2 - Metal Box



ELEVATION



Average depth of fill (H): ft Wearing surface density: pcf

Minimum cover depth (H_{min}): ft Wearing surface thickness: in

Water height: ft Thickness field measured (DW = 1.25 if checked)

Clear roadway width: ft

Pavement reduction factor: %

Comment:

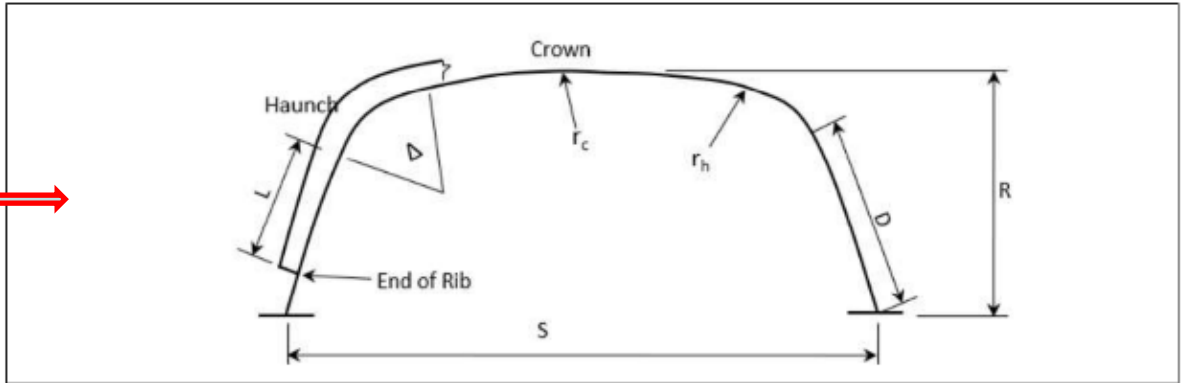
OK Apply Cancel



Metal Culvert Rating in BrR 7.4.1

- CULVERT DEFINITIONS
 - Culvert1 - CMP
 - Culvert2 - Metal Box
- Impact/Dynamic Load Allowance
- Roadway Plan View
- Culvert Loads
- CULVERT ALTERNATIVES
 - metal box 20ft span (E) (C)
 - Metal Box Culvert Geometry
 - Metal Box Culvert Properties
 - alum box 16ft span alt
 - Metal Box Culvert Geometry
 - Metal Box Culvert Properties
- BRIDGE ALTERNATIVES

Metal Box Culvert Geometry



Span (S): ft Delta: Degrees

Rise (R): ft D: ft

rc: ft L: ft

rh: ft Height of cover (H): ft

Pavement reduction factor: %

Comment:



Metal Culvert Rating in BrR 7.4.1

CULVERT DEFINITIONS

- Culvert1 - CMP
- Culvert2 - Metal Box**

CULVERT ALTERNATIVES

- metal box 20ft span (E) (C)
 - Metal Box Culvert Geometry
 - Metal Box Culvert Properties**
- alum box 16ft span alt
 - Metal Box Culvert Geometry
 - Metal Box Culvert Properties

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 Culvert Rating in BrR 7.4.1

Metal Box Culvert Properties

Material type: Steel Aluminum

Material:

Section properties

Name:

Mp crown: kip-ft/ft

Mp haunch: kip-ft/ft

Condition

Mp crown adjustment factor: %

Mp haunch adjustment factor: %

Library Data: Metal Box Culvert - Steel Metal Box

Name	Units	Rib Thickness	Rib Spacing	Shell thickness	Mp
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		30"	0.225	
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		30"	0.2	18.7
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		30"	0.25	17.7
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		30"	0.225	16.7
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		30"	0.2	15.6
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		30"	0.175	14.9
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		30"	0.25	
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		24"	0.111	14.2
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		24"	0.15	15.7
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		24"	0.175	17
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		24"	0.2	17.8
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		24"	0.225	19
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		24"	0.25	20.2
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		24"	0.2	21.3
Stl 6"x2" Corrugated Plate Angle Rib	US Customary		30"	0.15	13.7

- 16ft spiral rib steel
 - ⬇ Metal Pipe Culvert Geometry
 - ⬇ Metal Pipe Culvert Properties
 - ⬇ Metal Pipe Culvert Loads
- ☑ Culvert2 - Metal Box
 - ⬇ Impact/Dynamic Load Allowance
 - ⬇ Roadway Plan View
 - ⬇ Culvert Loads
 - 📁 CULVERT ALTERNATIVES
 - metal box 20ft span (E) (C)
 - Metal Box Culvert Geometry
 - ☑ Metal Box Culvert Properties
 - alum box 16ft span alt
 - Metal Box Culvert Geometry
 - ☑ Metal Box Culvert Properties
 - 📁 BRIDGE ALTERNATIVES
 - ☑ culvert1 (F) (C)



Metal Culvert Rating in BrR 7.4.1

The screenshot shows a software interface with a tree view on the left and a 'Metal Box Culvert Properties' dialog box on the right.

Tree View:

- Culvert2 - Metal Box
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
 - CULVERT ALTERNATIVES
 - metal box 20ft span (E) (C)
 - Metal Box Culvert Geometry
 - Metal Box Culvert Properties
 - alum box 16ft span alt (highlighted)
 - Metal Box Culvert Geometry
 - Metal Box Culvert Properties (highlighted)
 - BRIDGE ALTERNATIVES
 - culvert1 (E) (C)
 - CULVERTS

Metal Box Culvert Properties

Material type: Steel Aluminum

Material: Structural Plate 0.176-0.250

Section properties

Copy from library

Name: Alum 9 x 2 1/2 Corrugation Metal Box

Mp crown: 20.09 kip-ft/ft

Mp haunch: 20.09 kip-ft/ft

Condition

Mp crown adjustment factor: 100 %

Mp haunch adjustment factor: 100 %

OK Apply Cancel



Metal Culvert Rating in BrR 7.4.1

Analysis setting

The screenshot shows the 'BRIDGE WORKSPACE' software interface. The top menu bar includes 'BRIDGE WORKSPACE', 'WORKSPACE', and 'TOOLS'. The 'Analysis Settings' menu is highlighted, showing options like 'Analyze', 'Analysis Events', 'Tabular Results', and 'Specification Check Detail'. Below the menu is a 'Workspace' section with 'Bridge' and 'Components' tabs. The 'Components' tab is active, showing a tree view for 'MetalCulvertExample1' with sub-items: Components, Diaphragm Definitions, Lateral Bracing Definitions, MPF LRFD Multiple Presence Factors, EC Environmental Conditions, DP Design Parameters, SUPERSTRUCTURE DEFINITIONS, and CULVERT DEFINITIONS.



The screenshot shows the 'Rating method' settings dialog box. The 'Rating method' is set to 'LRFDR'. The 'Apply preference setting' is set to 'None'. The dialog has buttons for 'Refresh', 'Temporary vehicles', and 'Advanced'. Below these is a 'Vehicle summary' section with a tree view of rating vehicles. The tree is highlighted in yellow and includes: Rating vehicles, LRFDR, Design load rating, Inventory (HL-93 (US)), Operating (HL-93 (US)), Fatigue, Legal load rating, Routine (EV2, OH-2F1, OH-3F1, OH-5C1, Type 3, Type 3-3, Type 3S2), Specialized hauling (SU4, SU5, SU6, SU7), Permit load rating, EV3, Adjacent vehicle, RPL 60T, Adjacent vehicle, RPL 65T, Adjacent vehicle. There are 'Add to' and 'Remove from' buttons with '>>' and '<<' symbols. At the bottom are 'Save template', 'OK', 'Apply', and 'Cancel' buttons.



Metal Culvert Rating in BrR 7.4.1

Culvert Definition

Name:

Description:

Default units:

Existing	Current	Culvert alternative name	Description
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	10ft CMP	
<input type="checkbox"/>	<input type="checkbox"/>	16ft spiral rib steel	

OK Apply Cancel

Warning - The HL-93 (US) lane load will not



Metal Culvert Rating in BrR 7.4.1

Analysis Settings Analyze Analysis Events Tabular Results Specification Check Detail Engine Outputs Results

Workspace

Bridge Components

MetalCulvertExample1

- Components
- Diaphragm Definitions
- Lateral Bracing Definitions
- CULVERT DEFINITIONS
 - Culvert1 - CMP
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
 - CULVERT ALTERNATIVES
 - 10ft CMP (E) (C)
 - 16ft spiral rib steel
 - Culvert2 - Metal Box
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
 - CULVERT ALTERNATIVES
 - metal box 20ft span (E) (C)
 - alum box 16ft span alt
- BRIDGE ALTERNATIVES
 - culvert1 (E) (C)
 - CULVERTS

Analysis

Analysis - MetalCulvertExample1

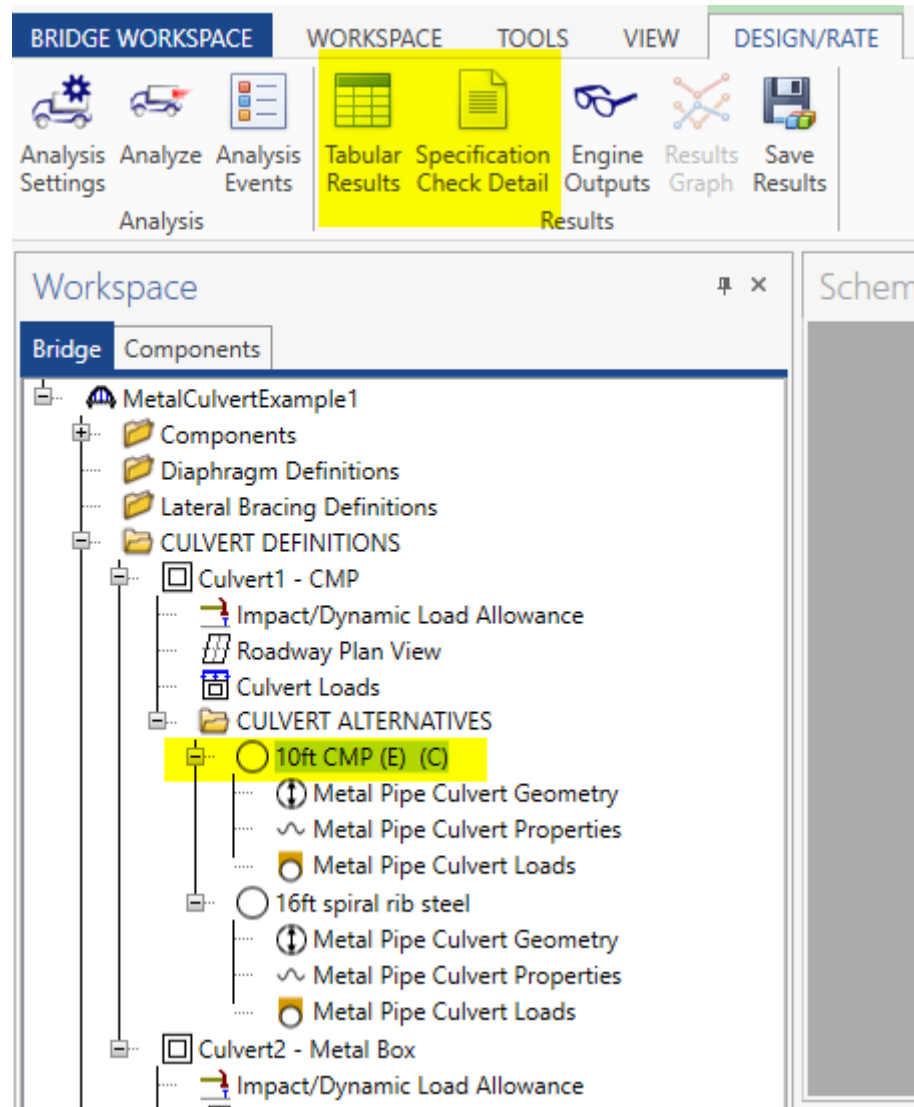
- Analysis Event
 - MetalCulvertExample1
 - CULVERTS
 - Culvert 1 [Culvert1 - CMP] [10ft CMP]
 - Culvert 2 [Culvert2 - Metal Box] [metal box 20ft spa]

Interims

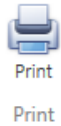
- Info - Analyzing metal b
- Metal Culvert Engine...
- Warning - The HL-93 (U
- Info - Performing LRFR
- Info - metal box 20ft spa
- STAGE 3
- Culvert - metal box :
- Completed Specification
- Info - LRFR analysis suc
- Info - Analysis complete



Metal Culvert Rating in BrR 7.4.1



Metal Culvert Rating in BrR 7.4.1



RESULTS - Workspace

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	Limit State	Impact	Lane
EV2	Axle Load	LRFR	Legal	26.32	0.915	STRENGTH-I Plastic Moment	As Requested	As Requested
HL-93 (US)	Axle Load	LRFR	Inventory	39.43	1.095	STRENGTH-I Plastic Moment	As Requested	As Requested
HL-93 (US)	Axle Load	LRFR	Operating	51.11	1.420	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
HL-93 (US)	Tandem	LRFR	Operating	65.42	1.817	STRENGTH-I Plastic Moment	As Requested	As Requested
OH-2F1	Axle Load	LRFR	Legal	23.00	1.533	STRENGTH-I Plastic Moment	As Requested	As Requested
OH-3F1	Axle Load	LRFR	Legal	41.49	1.804	STRENGTH-I Plastic Moment	As Requested	As Requested
OH-5C1	Axle Load	LRFR	Legal	72.15	1.804	STRENGTH-I Plastic Moment	As Requested	As Requested
SU4	Axle Load	LRFR	Legal	48.70	1.804	STRENGTH-I Plastic Moment	As Requested	As Requested
SU5	Axle Load	LRFR	Legal	55.92	1.804	STRENGTH-I Plastic Moment	As Requested	As Requested
SU6	Axle Load	LRFR	Legal	62.68	1.804	STRENGTH-I Plastic Moment	As Requested	As Requested
SU7	Axle Load	LRFR	Legal	69.90	1.804	STRENGTH-I Plastic Moment	As Requested	As Requested
Type 3	Axle Load	LRFR	Legal	45.10	1.804	STRENGTH-I Plastic Moment	As Requested	As Requested
Type 3-3	Axle Load	LRFR	Legal	76.66	1.917	STRENGTH-I Plastic Moment	As Requested	As Requested
Type 3S2	Axle Load	LRFR	Legal	71.22	1.978	STRENGTH-I Plastic Moment	As Requested	As Requested
EV3	Axle Load	LRFR	Permit	77.34	1.799	STRENGTH-II Plastic Moment	As Requested	As Requested
RPL 60T	Axle Load	LRFR	Permit	126.45	2.108	STRENGTH-II Plastic Moment	As Requested	As Requested
RPL 65T	Axle Load	LRFR	Permit	166.10	2.555	STRENGTH-II Plastic Moment	As Requested	As Requested



Metal Culvert Rating in BrR 7.4.1

RESULTS - Workspace



Print

Print

Report type:

Rating Results Summary

Lane/Impact loading type

As requested Detailed

Display Format

Multiple rating levels per row

Live Load	Live Load Type	Rating Method	Inventory Load Rating (Ton)	Operating Load Rating (Ton)	Legal Load Rating (Ton)	Permit Load Rating (Ton)	Inventory Rating Factor	Operating Rating Factor	Legal Rating Factor	Permit Rating Factor	Inventory Limit State	Operating Limit State	Legal Limit State	Permit Limit State
EV2	Axle Load	LRFR			26.32				0.915				STRENGTH-I Plastic Moment	
HL-93 (US)	Axle Load	LRFR	39.43	51.11			1.095	1.420			STRENGTH-I Plastic Moment	STRENGTH-I Plastic Moment		
HL-93 (US)	Tandem	LRFR	50.47	65.42			1.402	1.817			STRENGTH-I Plastic Moment	STRENGTH-I Plastic Moment		
OH-2F1	Axle Load	LRFR			23.00				1.533				STRENGTH-I Plastic Moment	
OH-3F1	Axle Load	LRFR			41.49				1.804				STRENGTH-I Plastic Moment	
OH-5C1	Axle Load	LRFR			72.15				1.804				STRENGTH-I Plastic Moment	
SU4	Axle Load	LRFR			48.70				1.804				STRENGTH-I Plastic Moment	
SU5	Axle Load	LRFR			55.92				1.804				STRENGTH-I Plastic Moment	
SU6	Axle Load	LRFR			62.68				1.804				STRENGTH-I Plastic Moment	
SU7	Axle Load	LRFR			69.90				1.804				STRENGTH-I Plastic Moment	
Type 3	Axle Load	LRFR			45.10				1.804				STRENGTH-I Plastic Moment	
Type 3-3	Axle Load	LRFR			76.66				1.917				STRENGTH-I Plastic Moment	
Type 3S2	Axle Load	LRFR			71.22				1.978				STRENGTH-I Plastic Moment	
EV3	Axle Load	LRFR				77.34				1.799				STH-II Plastic Moment
RPL 60T	Axle Load	LRFR				126.45				2.108				STH-II Plastic Moment
RPL 65T	Axle Load	LRFR				166.10				2.555				STH-II Plastic Moment



Metal Culvert Rating in BrR 7.4.1

Report type:
 Rating Results Summary

Lane/Impact loading type
 As requested Detailed

Display Format
 Single rating level per row

Analysis Settings | Analyze | Analysis Events | **Tabular Results** | Specification Check Detail | Engine Outputs

Live Load	Live Load Type	Rating Method	Rating Level	Load Rating (Ton)	Rating Factor	Limit State	
EV2	Axle Load	LRFR	Legal	41.38	1.439	STRENGTH-I Plastic Moment	As Requested
HL-93 (US)	Axle Load	LRFR	Inventory	39.02	1.084	STRENGTH-I Plastic Moment	As Requested
HL-93 (US)	Axle Load	LRFR	Operating	57.81	1.606	STRENGTH-I Plastic Moment	As Requested
HL-93 (US)	Tandem	LRFR	Inventory	49.70	1.380	STRENGTH-I Plastic Moment	As Requested
HL-93 (US)	Tandem	LRFR	Operating	73.63	2.045	STRENGTH-I Plastic Moment	As Requested
OH-2F1	Axle Load	LRFR	Legal	40.77	2.718	STRENGTH-I Plastic Moment	As Requested
OH-3F1	Axle Load	LRFR	Legal	41.17	1.790	STRENGTH-I Plastic Moment	As Requested
OH-5C1	Axle Load	LRFR	Legal	71.60	1.790	STRENGTH-I Plastic Moment	As Requested
SU4	Axle Load	LRFR	Legal	41.32	1.530	STRENGTH-I Plastic Moment	As Requested
SU5	Axle Load	LRFR	Legal	51.15	1.650	STRENGTH-I Plastic Moment	As Requested
SU6	Axle Load	LRFR	Legal	49.59	1.427	STRENGTH-I Plastic Moment	As Requested
SU7	Axle Load	LRFR	Legal	48.73	1.258	STRENGTH-I Plastic Moment	As Requested
Type 3	Axle Load	LRFR	Legal	41.25	1.650	STRENGTH-I Plastic Moment	As Requested
Type 3-3	Axle Load	LRFR	Legal	74.78	1.870	STRENGTH-I Plastic Moment	As Requested
Type 3S2	Axle Load	LRFR	Legal	72.11	2.003	STRENGTH-I Plastic Moment	As Requested
EV3	Axle Load	LRFR	Permit	75.85	1.764	STRENGTH-II Plastic Moment	As Requested
RPL 60T	Axle Load	LRFR	Permit	134.75	2.246	STRENGTH-II Plastic Moment	As Requested
RPL 65T	Axle Load	LRFR	Permit	128.60	1.978	STRENGTH-II Plastic Moment	As Requested

Workspace


Bridge Components

- MetalCulvertExample1
 - Components
 - Diaphragm Definitions
 - Lateral Bracing Definitions
 - CULVERT DEFINITIONS
 - Culvert1 - CMP
 - Culvert2 - Metal Box
 - Impact/Dynamic Load Allowance
 - Roadway Plan View
 - Culvert Loads
 - CULVERT ALTERNATIVES
 - metal box 20ft span (E) (C)
 - alum box 16ft span alt
 - BRIDGE ALTERNATIVES
 - culvert1 (E) (C)
 - CULVERTS




Metal Culvert Rating in BrR 7.4.1

RESULTS – Bridge Explorer

 Bridge Rating Results

System of units: US customary SI / metric

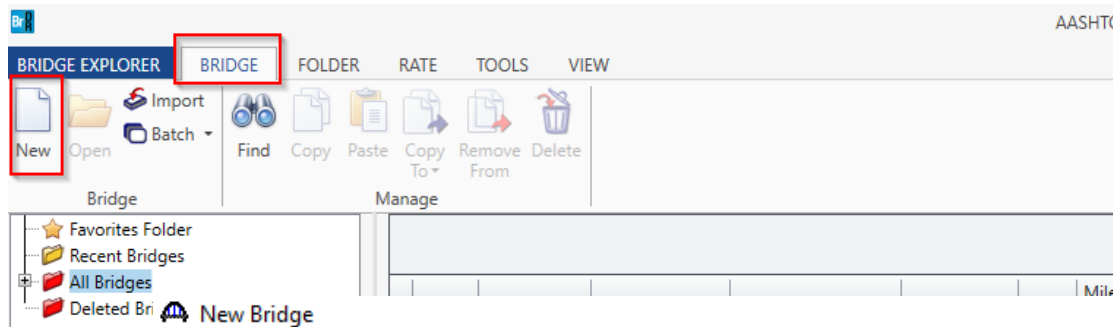
Lane/impact loading type: As requested Detailed

Display format: 

Bridge ID	Vehicle	Rating level	Rating factor	Rating method	Capacity (Ton)	Time stamp	Rated by
MetalCulvertExample1	EV2	Legal	0.915	LRFR	26.317	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	HL-93 (US)	Inventory	1.084	LRFR	39.024	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	HL-93 (US)	Operating	1.420	LRFR	51.109	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	OH-2F1	Legal	1.533	LRFR	22.999	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	OH-3F1	Legal	1.790	LRFR	41.171	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	OH-5C1	Legal	1.790	LRFR	71.602	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	SU4	Legal	1.530	LRFR	41.319	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	SU5	Legal	1.650	LRFR	51.148	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	SU6	Legal	1.427	LRFR	49.589	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	SU7	Legal	1.258	LRFR	48.728	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	Type 3	Legal	1.650	LRFR	41.249	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	Type 3-3	Legal	1.870	LRFR	74.781	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	Type 3S2	Legal	1.978	LRFR	71.222	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	EV3	Permit	1.764	LRFR	75.848	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	RPL 60T	Permit	2.108	LRFR	126.455	Thursday, August 3, 2023 11:53:...	awaheed
MetalCulvertExample1	RPL 65T	Permit	1.978	LRFR	128.602	Thursday, August 3, 2023 11:53:...	awaheed



Metal Culvert Rating in BrR 7.4.1



Bridge ID: NBI structure ID (8):

Template Superstructures
 Bridge completely defined Culverts
 Substructures

Description | Description (cont'd) | Alternatives | Global reference point | Traffic | Custom agency fields

Name: Year built:

Description:

Location: Length: ft

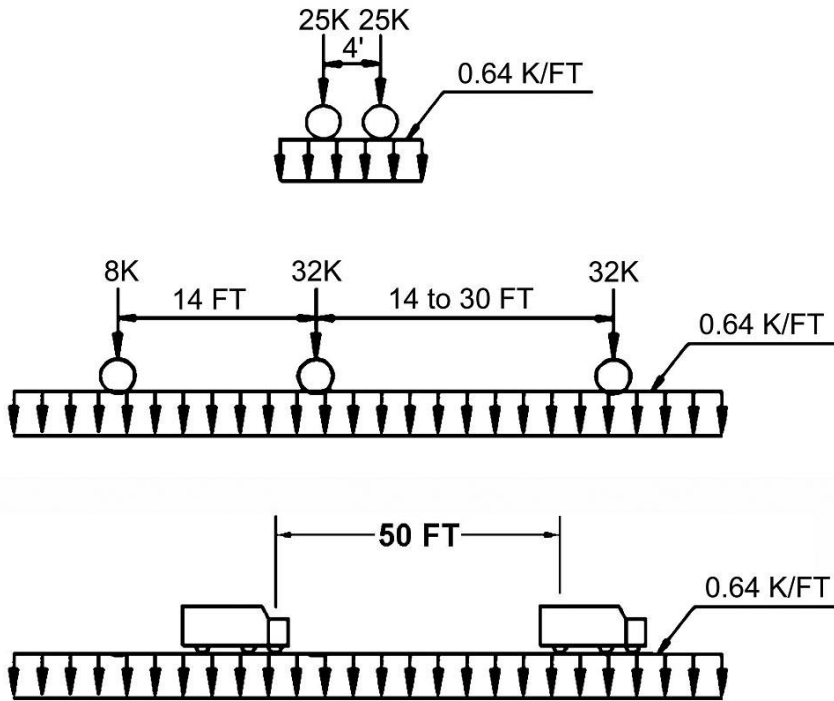
Facility carried (7): Route number:

Feat. intersected (6): Mi. post:

Default units:



Metal Culvert Rating in BrR 7.4.1



All Axle Loads in kips



EV2, weight = 57.5 kips (28.75 tons)

HL-93 Design Loading



Metal Culvert Rating in BrR 7.4.1

The screenshot shows a software interface with a 'Workspace' on the left and a 'Culvert Definition' dialog box in the center. The workspace contains a tree view with folders: Components, Diaphragm Definitions, Lateral Bracing Definitions, CULVERT DEFINITIONS (highlighted with a red arrow), and BRIDGE ALTERNATIVES. The dialog box has the following fields:

- Name: CMP Culvert
- Description: (empty text box)
- Default units: US Customary

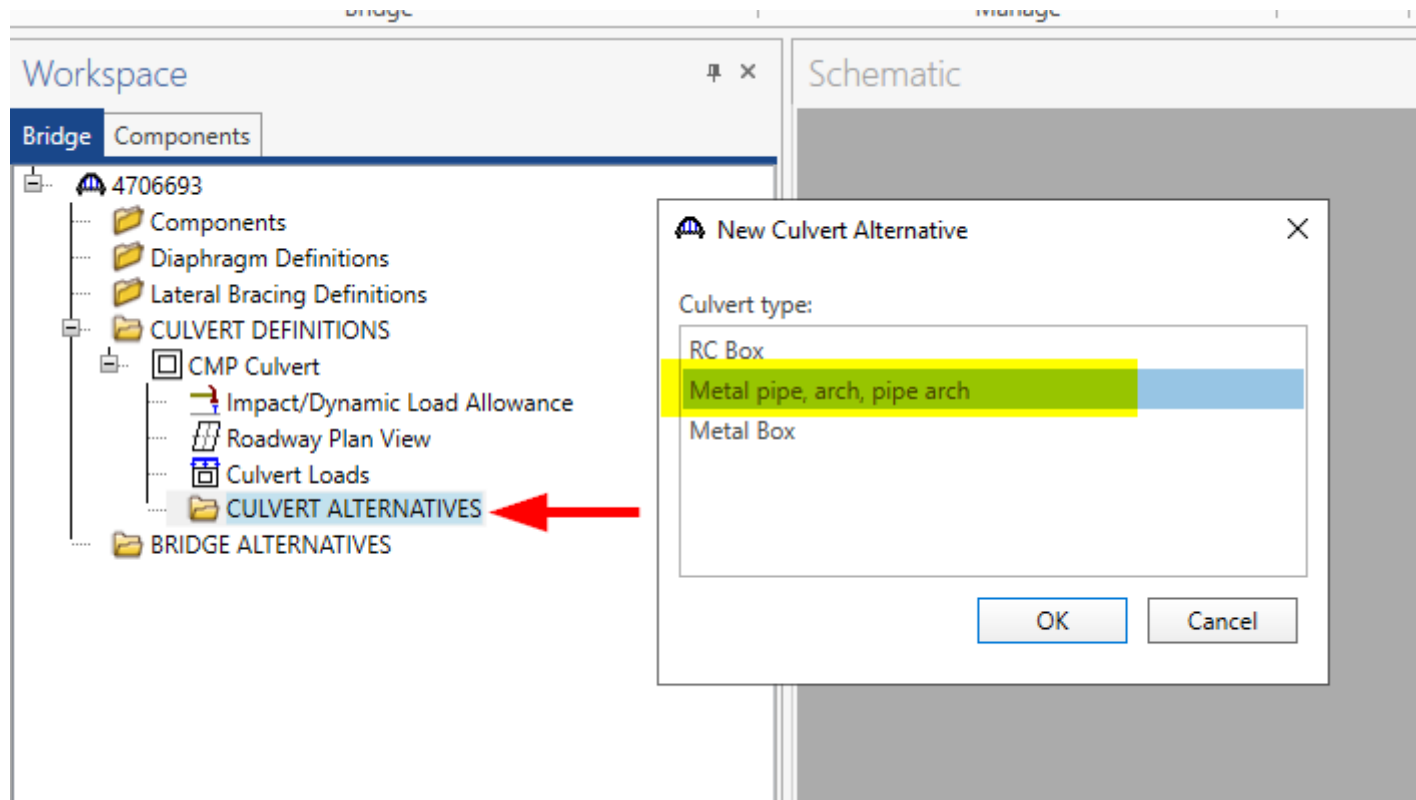
Below the fields is a table with the following columns:

Existing	Current	Culvert alternative name	Description

At the bottom of the dialog are three buttons: OK, Apply, and Cancel.



Metal Culvert Rating in BrR 7.4.1



Metal Culvert Rating in BrR 7.4.1

The screenshot displays the 'Culvert Alternative Description' window in a software application. On the left, a 'Workspace' pane shows a project tree with 'CULVERT ALTERNATIVES' selected. The main window has a title bar 'Culvert Alternative Description' and a search field containing 'CMP Culvert'. Below this are tabs for 'Description', 'Specs', 'Factors', and 'Control options'. The 'Description' tab is active, showing a text field for 'Description' with the value 'New CMP Culvert'. To the right, 'Culvert type' is set to 'Metal pipe, arch, pipe arch'. Below that, 'Default units' is 'US Customary' and 'Default rating method' is 'LRFR'. The 'Structure type' dropdown menu is open, showing options: 'Corrugated metal pipe' (highlighted), 'Corrugated metal pipe', 'Spiral rib metal pipe', and 'Structural plate pipe'. The 'Duncan and Drawsky' section is collapsed. At the bottom, 'Backfill material type' is 'GW,GP&SW,SP' and 'Relative compaction (%)' is '90'.



Questions

Amjad Waheed, PE
OHDOT Bridge Rating Engineer

Amjad.Waheed@dot.ohio.gov

614-752-9972

