Ohio Transportation Engineering Conference

2012

October 31, 2012

Mitch Hardert
Chief Engineer – CBC Engineers

Jim Noll
Director Engineering Services – CONTECH

Joe Dennis
Director Business Development – CBC Engineers
Why Load Rate Structures?

- Federal Highway Administration (FHWA) requires load ratings of all the structures of length (Span) 20 feet or greater in compliance with National Bridge Inspection Standards (NBIS)

- For the safety of general public and traffic using highway structures, the loading rating is performed.

- ODOT has begun to create the Statewide Culvert Inventory which will require field inspection and load rating of structures of length (Span) of less than 20 feet. This will be similar to the NBIS for bridges. Estimate 3 to 5 culverts for every bridge on the NBIS.

INTRODUCTION
This manual of Culvert Inspection and Inventory procedures has been prepared to provide a tool for the inventory, periodic inspection, and the maintenance of culverts and structures with less than a 10-foot span. The intent is to provide a mechanism to aid in the inventory of culverts and storm sewers under pavement, and provide a regular and systematic inspection of culverts on the public highways and streets in the interest of public safety, and to protect the public’s investment with routine maintenance items.”
Among the Key Findings:

• **Age** – usually built to last 50 years, the average bridge in this country is 43 years old; almost 20 percent of these are over 50.

• **The Price Tag** – according to new data from FHWA, the cost to repair or modernize these bridges is at least $140 Billion, assuming they are Fixed immediately.

• **Soaring Construction Costs** – cost of steel, asphalt, and concrete, have risen by 41% over past four years. Nearly every state faces future funding shortfalls to keep up with demand.

**ODOT joins other States in Request For more Federal Investment in Bridge Safety**

National Study shows $140 Billion Price Tag to Repair and Modernize America’s Baby Boomer Bridges

**Among the Key Findings:**
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)
- The AASHTO Standard Specification for Highway Bridges (Ref. 2)

<table>
<thead>
<tr>
<th>June 1995</th>
<th>NATIONAL CORRUGATED STEEL PIPE ASSOCIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174</td>
</tr>
<tr>
<td></td>
<td>(202) 452 -1700 – Fax (202) 833-3636</td>
</tr>
</tbody>
</table>

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Jim Noll – Director Engineering Services - CONTECH

Ohio Transportation Engineering Conference 2012

October 31, 2012

Mitch Hardert
Chief Engineer – CBC Engineers

Jim Noll
Director Engineering Services – CONTECH

Joe Dennis
Director Business Development – CBC Engineers
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

- Pick a Structure
- Take Field Shape Readings
- Shape Plots
- More Field Observations

Load Rating Flexible Buried Culverts
Understanding Design of Flexible Buried Culverts

\[ C = P_v \times \frac{S}{2} \]

- \( C \) = RING COMPRESSION, lb/ft (kN/m)
- \( P_v \) = VERTICAL PRESSURE, lb/ft (kN/m)
- \( S \) = SPAN, ft (m)
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Load Intensity @ top of a Corrugated Metal Conduit

TOTAL LOAD = P

where

P = P_e + P_1
Proper Installation Controls Long Term Deflection

Select Backfill

P

In-situ Fill

Installation & Structure Deflection
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Installation & Structure Deflection
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Existing Structure Geometry

First Indicator of Future Performance
How Flat is too Flat?

Reduces Load Carrying Capabilities
How Flat is too Flat?

Reverse Curvature

This is Too Much

Dimensional / Field Measurement is Critical
DEFLECTION STABILITY

How Flat is too Flat?

- A through R represent dimensions monitored at each station.
- 1 through 4 represent the most distant points from the center to left, up, right and down.

Determine Structure Shape by Using Chords & Mid-Ordinates
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Pick a Structure

Take Field Shape Readings

Shape Plots

More Field Observations

Load Rating Flexible Buried Culverts
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Laser Shape Readings

Speed Field Measurements While Improving Accuracy
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Plot The Field Measurements Using CAD
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Plot The Field Measurements Using CAD
MULTSPAN Program - Shape Evaluation

**Calculates:**
- Radii of Structure
- Average, Maximum and Minimum Values for:
  - Chords
  - Mid-ordinates
  - Radii
- % Deflection or Peaking Mid-ordinates
- Soil Pressure
- Stress
- Factor of Safety
- % Leaning

**Recommends:**
- Load De-rating (Close The Road)
- Frequency of Evaluation
- Further Geotechnical Evaluations

**Goal for Using MULTSPAN Program**
Example of a MULTSPAN Output Showing % Mid-ordinate Change

<table>
<thead>
<tr>
<th>STA</th>
<th>Top Center Mid-ordinate</th>
<th>Top Left Mid-ordinate</th>
<th>Top Right Mid-ordinate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Des Value</td>
<td>Present Value</td>
<td>% Diff</td>
</tr>
<tr>
<td>1</td>
<td>5.01</td>
<td>4.95</td>
<td>+1.26</td>
</tr>
<tr>
<td>2</td>
<td>5.01</td>
<td>4.66</td>
<td>+7.05</td>
</tr>
<tr>
<td>3</td>
<td>5.01</td>
<td>4.58</td>
<td>+8.64</td>
</tr>
<tr>
<td>4</td>
<td>5.01</td>
<td>4.63</td>
<td>+7.64</td>
</tr>
<tr>
<td>5</td>
<td>5.01</td>
<td>4.97</td>
<td>+0.85</td>
</tr>
</tbody>
</table>
## MULTISPAN Recommendations

<table>
<thead>
<tr>
<th>Mid-ordinate % change</th>
<th>Depth Of Cover (ft)</th>
<th>Recommended Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 15 %</td>
<td>Any</td>
<td>No Action Required.</td>
</tr>
<tr>
<td>15 – 20 %</td>
<td>Over 6.0</td>
<td>No Action Required.</td>
</tr>
<tr>
<td>15 – 20 %</td>
<td>Under 6.0</td>
<td>Monitor on 6-month interval.</td>
</tr>
<tr>
<td>20 – 25 %</td>
<td>Over 6.0</td>
<td>Reduce legal load to 90% of H-20 and monitor on 6-month intervals.</td>
</tr>
<tr>
<td>20 – 25 %</td>
<td>Under 6.0</td>
<td>Reduce legal load to 75% of H-20 and monitor on 6-month intervals.</td>
</tr>
<tr>
<td>25 – 30 %</td>
<td>Over 6.0</td>
<td>Reduce legal load to 75% of H-20 and monitor on 6-month intervals.</td>
</tr>
<tr>
<td>25 – 30 %</td>
<td>3.0 – 6.0</td>
<td>Reduce legal load to 50% of H-20 and monitor on 6 month intervals.</td>
</tr>
<tr>
<td>25 – 30 %</td>
<td>Under 3.0</td>
<td>Reduce legal load to 50% of H-20 and do detailed analysis.</td>
</tr>
<tr>
<td>&gt; 30 %</td>
<td>Any</td>
<td>Close road until detailed analysis is done.</td>
</tr>
</tbody>
</table>
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Almost Ready for Bridge rating, MULTSPAN rating & Load rating

Pick a Structure

Take Field Shape Readings

Shape Plots

More Field Observations

Load Rating Flexible Buried Culverts
Leaning / Sagging

Bolt Hole Cracking

Invert Condition

Wall Buckling

Seam Lap & Missing Bolts

Headwall Condition

Corrosion / Wall Area

Deflection

FIELD VISUAL OBSERVATIONS
FIELD VISUAL OBSERVATIONS

- Sagging / Racking
- Cracking
- Distortion / Deflection
- Missing Bolts
- Headwall Deterioration
- Sedimentation
- Backfill Material
- Backfill Compaction

Conclusions:

- Ready for MULTSPAN Analysis
- Ready for NBIS Type Rating
- Ready for Load Rating
### NBIS Type Structure Rating

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>% CHANGE TOP M.O. HEIGHT</td>
<td>0 to 6</td>
</tr>
<tr>
<td>% CHANGE LEFT/RIGHT TOP M.O.</td>
<td>0 to 6</td>
</tr>
<tr>
<td>% LEANING</td>
<td>0 to 6</td>
</tr>
<tr>
<td>GENERAL SHAPE</td>
<td>0 to 6</td>
</tr>
<tr>
<td>METAL CONDITION</td>
<td>0 to 6</td>
</tr>
<tr>
<td>SEAM CONDITION</td>
<td>0 to 6</td>
</tr>
<tr>
<td>HEADWALL CONDITION</td>
<td>0 to 6</td>
</tr>
<tr>
<td>OVERALL RATING</td>
<td>0 to 6</td>
</tr>
<tr>
<td>POSSIBLE RATING</td>
<td>0 to 48</td>
</tr>
</tbody>
</table>

Rating Flexible Buried Culverts
<table>
<thead>
<tr>
<th>Description of Structure</th>
<th>NATIONAL BRIDGE INSPECTION RATING</th>
<th>&quot;A&quot; UNIFORM DETERIORATION</th>
<th>&quot;B&quot; CATEGORICAL DETERIORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Condition</td>
<td>9</td>
<td>47 to 48</td>
<td></td>
</tr>
<tr>
<td>Good Condition – no repairs needed</td>
<td>8</td>
<td>43 to 46</td>
<td>5 to 6</td>
</tr>
<tr>
<td>Generally Good Condition – potential exists for minor maintenance</td>
<td>7</td>
<td>39 to 42</td>
<td></td>
</tr>
<tr>
<td>Fair Condition – potential exists for major maintenance</td>
<td>6</td>
<td>35 to 38</td>
<td>4</td>
</tr>
<tr>
<td>Generally Fair Condition – potential exists for minor rehabilitation</td>
<td>5</td>
<td>32 to 34</td>
<td></td>
</tr>
<tr>
<td>Marginal Condition – potential exists for major rehabilitation</td>
<td>4</td>
<td>28 to 31</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Poor Condition – repair or rehabilitation required immediately</td>
<td>3</td>
<td>21 to 27</td>
<td></td>
</tr>
<tr>
<td>Critical Condition – need for repair is urgent. Close structure until the repair is completed</td>
<td>2</td>
<td>12 to 20</td>
<td></td>
</tr>
<tr>
<td>Critical Condition – structure is closed, determine the feasibility for repair</td>
<td>1</td>
<td>6 to 11</td>
<td>0 to 1</td>
</tr>
<tr>
<td>Critical Condition – structure is closed and is beyond repair</td>
<td>0</td>
<td>0 to 5</td>
<td></td>
</tr>
</tbody>
</table>

Rating Flexible Buried Culverts
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Mitch Hardert – Chief Engineer – CBC Engineers

Ohio Transportation Engineering Conference 2012

October 31, 2012

Mitch Hardert
Chief Engineer – CBC Engineers

Jim Noll
Director Engineering Services – CONTECH

Joe Dennis
Director Business Development – CBC Engineers
What is Load Rating?

The safe live load carrying capacity of a highway structure is called its load rating. It is usually expressed as a rating factor (RF) or in terms of tonnage for a particular vehicle.

Load rating is different from Inspection rating.

Load Rating Flexible Buried Culverts
The load rating of a bridge should be revised when:

1. There is a physical change in the condition of a bridge or a structural member of the bridge.
   a) There is an alteration in the structure
   b) A new member is added
   c) A member’s width, weight, or thickness is changed
   d) Rusting, spalling, or damage to a member that has resulted in section loss
   e) Changes in the dead loads on the structure, like addition or removal of wearing surfaces, sidewalks, parapets, railings, etc
   f) Structural damages in members due to accidents, like a hit by a vehicle
The load rating of a bridge should be revised when:

2. There is a request to re-evaluate the rating of a structure for a different vehicle

3. There is a change from the method of analysis used for previous rating

4. Special circumstances that require re-analysis of the structure
AASHTO Load Rating Methods

Three Load Rating Methods:
1. Working (Allowable) Stress Rating (WSR)
2. Load Factor Rating (LFR)
3. Load and Resistance Factor Rating (LRFR)

Load Factor Rating (LFR):
- Older Buried Flexible Structures were designed using ASD
- CMP = 100 years, SSP = since 1931
- ALSP = 1960’s, ALBC = 1970’s
- New & Old Buried Flexible Structure ratings should use LFR
- Places load factors on Dead Loads and Live Loads and takes the capacity up to yield/ultimate/plastic for the material.

Load Rating Flexible Buried Culverts
AASHTO Load Rating Method

The load rating on each bridge is determined for:

- **Inventory Stress Level**
  - Lower stress level
  - Design Stress Level

- **Operating Stress Level**
  - Higher stress level
  - ODOT uses to post bridges
  - Maximum permissible live load to which the structure may be subjected

Load Rating Flexible Buried Culverts
AASHTO Load Rating Method

Truck Types Used to Load Rate Bridges in Ohio

**Inventory Load Rating**
1. HS 20

**Operating Load Rating**
1. HS 20
2. 2F1 (2 axle)
3. 3F1 (3 axle)
4. 4F1 (4 axle)
5. 5C1 (5 axle)

Load Rating Flexible Buried Culverts
AASHTO Load Rating Method

Truck Types Used to Load Rate Bridges in Ohio

Inventory & Operating Load Rating
AASHTO HS20 Truck

Gross Vehicle Weight = 36 tons

Load Rating Flexible Buried Culverts
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Ohio Legal Load (2F1)

GVW = 15 tons

Load Rating Flexible Buried Culverts
Ohio Legal Load (3F1)

GVW = 23 tons

10'

12k

17k

17k

Load Rating Flexible Buried Culverts
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

**Ohio Legal Load (4F1)**

- **10'**
- **4'**
- **4'**
- **GVW = 27 tons**

Load Rating Flexible Buried Culverts
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Ohio Legal Load (5C1)

GVW = 40 tons

Rating Flexible Buried Culverts
Basic Load Rating Equation

\[ RF = \frac{\text{Capacity} - \text{DL}}{(\text{LL} + \text{I})} \]

- \( RF \) = Rating Factor
- \( DL \) = Dead Load
- \( LL \) = Live Load
- \( I \) = Impact

- Factors up DL and (LL+I)
- Capacity is at Yield/Ultimate/Plastic
- Gives higher RF

Load Rating Flexible Buried Culverts
**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)
- The AASHTO Standard Specification for Highway Bridges (Ref. 2)

June 1995

**NATIONAL CORRUGATED STEEL PIPE ASSOCIATION**

1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174
(202) 452 -1700 – Fax (202) 833-3636

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.

**Load Rating Flexible Buried Culverts**
### Load Rating and Structural Evaluation of In-Service, Corrugated Steel Structures

**Load rating, Basic AASHTO Equations:**

Max. Strength = 1.3[βD + RF (L+I)] – Operating Load  
Max. Strength = 1.3[βD + 5/3 RF(L + I)] – Inventory Load

**Where:**
- Max. Strength is the max. design strength ($T_{cap}$)
- RF = Rating Factor
- D = Dead Load ($T_E$)
- L + I = Live Load + Impact
- 1.3 = Load Factor $\gamma$
- $\beta$ = load Factor
  - Note: $\beta = 1.0$ for conventional bridges
  - $\beta = 1.5$ for Ring Compression Structures

**NCSPA Design Data Sheet No. 19**

---

**June 1995**

**NATIONAL CORRUGATED STEEL PIPE ASSOCIATION**

1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174
(202) 452 -1700 – Fax (202) 833-3636

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.

---

**Load Rating Flexible Buried Culverts**
### Load Rating And Structural Evaluation of In-Service, Corrugated Steel Structures

Impact Loads (I) for buried structures with cover (H) less than 3 feet:

<table>
<thead>
<tr>
<th>H Range</th>
<th>I (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>H &lt; 1'-0&quot;</td>
<td>30%</td>
</tr>
<tr>
<td>1'-1&quot; &lt; H &lt; 2'-0&quot;</td>
<td>20%</td>
</tr>
<tr>
<td>2'-1&quot; &lt; H &lt; 2'-11&quot;</td>
<td>10%</td>
</tr>
</tbody>
</table>

Section 3.30 of AASHTO specifications assumes a rectangular tire contact pattern with an area A in square inches equal to 1% of the wheel load, P, in pounds. P is ½ of the axle load and should include any impact.

June 1995

**NATIONAL CORRUGATED STEEL PIPE ASSOCIATION**

1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174

(202) 452 -1700 – Fax (202) 833-3636

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

**NCSPA Design Data Sheet No. 19**

**Load Rating and Structural Evaluation of In-Service, Corrugated Steel Structures**

**Table C.3.1 Live Load Pressures for Design (AASHTO):**

<table>
<thead>
<tr>
<th>Height of Cover, ft.</th>
<th>H20 Loading, psf</th>
<th>H25 Loading, psf</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2270</td>
<td>2580</td>
</tr>
<tr>
<td>2</td>
<td>850</td>
<td>1000</td>
</tr>
<tr>
<td>3</td>
<td>420</td>
<td>510</td>
</tr>
<tr>
<td>4</td>
<td>285</td>
<td>350</td>
</tr>
<tr>
<td>5</td>
<td>210</td>
<td>250</td>
</tr>
<tr>
<td>6</td>
<td>160</td>
<td>190</td>
</tr>
<tr>
<td>7</td>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td>9</td>
<td>_</td>
<td>100</td>
</tr>
</tbody>
</table>

June 1995

**NATIONAL CORRUGATED STEEL PIPE ASSOCIATION**

1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174
(202) 452 -1700 – Fax (202) 833-3636

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.

Load Rating Flexible Buried Culverts
### Load Rating and Structural Evaluation of In-Service, Corrugated Steel Structures

Using Basic AASHTO Equations & Solving for RF (Rating Factors):

**Operating Load** Rating Factor \( (RF_o) \) is the lower of the two values based on wall strength or minimum cover requirements.

#### RF<sub>o</sub> Based on wall Strength:

\[
RF_{o-w} = \frac{T_{cap} - 1.95 \ T_E}{1.3 \ T_{(L+I)}}
\]

- \( T_E \) = pipe wall thrust due to earth cover & is higher value of:
  - a) \( \gamma H \ (S/2) \)
  - b) \( \gamma H \ (R_t) \)

- \( T_{(L+I)} \) = pipe wall thrust due to live load + impact and is the greater of:
  - a) \( (P_{L+I})^{S/2} \)
  - b) \( (P_{L+I})^{R_t} \)

\( T_{cap} \) = thrust capacity of wall. It is lesser of:
- a) Wall Yield Strength = \( F_y A \)
- b) Wall Buckling Strength = \( F_{crit} A \)
- c) Seam Strength = .67 (seam strength)

---

**NCSPA Design Data Sheet No. 19**

**Load Rating and Structural Evaluation of In-Service, Corrugated Steel Structures**

June 1995

NATIONAL CORRUGATED STEEL PIPE ASSOCIATION
1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174
(202) 452-1700 – Fax (202) 833-3636

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.
Load Rating And Structural Evaluation of In-Service, Corrugated Steel Structures

Using Basic AASHTO Equations & Solving for RF (Rating Factors):

**Operating Load** Rating Factor ($RF_o$) is the lower of the two values based on wall strength or minimum cover requirements.

$RF_o$ Based on Cover Requirements:

$$RF_{o-c} = \frac{H^2}{C(h)^2}$$

- $H$ is the lowest actual cover over the structure in an area based on field measurements:
- $h$ is the AASHTO Minimum Cover level for the structure (Span/8) or others for Long-Span or Box Culvert shapes or heavier loads like RR.
- $C = 2.36 \frac{H}{S} + 0.528 \leq 1.0$

Load Rating Flexible Buried Culverts
NCSPA Design Data Sheet No. 19

Load Rating and Structural Evaluation of In-Service, Corrugated Steel Structures

Using Basic AASHTO Equations & Solving for RF (Rating Factors):

**Inventory Load** Rating Factor ($RF_i$) can be determined from the operating load Rating Factor ($RF_o$) or from the minimum cover requirements. It is the lowest value of:

- $RF_i$ Based on $RF_o$:
  \[
  RF_i = \frac{3}{5} \times RF_{o-w}
  \]

- $RF_i$ Based on Minimum Cover Requirements:
  \[
  RF_i = \frac{H^2}{(h)^2}
  \]
  - $H$ is the lowest actual cover over the structure in the traffic area based on field measurement.
  - $h$ is the AASHTO Minimum Cover level for the structure (Span/8) or others for Long-Span or Box Culvert shapes or heavier loads like RR.

June 1995

NATIONAL CORRUGATED STEEL PIPE ASSOCIATION
1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174
(202) 452 -1700 – Fax (202) 833-3636

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.

Load Rating Flexible Buried Culverts
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

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 Ratings (Based on H/HS Truck):

Operating Loads:
- Axle Load = $RF_o (32)$ (in kips)
- H/HS Truck = $RF_o (GVW)$
  - H Truck = $RF_o (20)$ (in tons)
  - HS Truck = $RF_o (36)$ (in tons)

Inventory Loads:
- Axle Load = $RF_i (32)$ (in kips)
- H/HS Truck = $RF_i (GVW)$
  - H Truck = $RF_i (20)$ (in tons)
  - HS Truck = $RF_i (36)$ (in tons)

June 1995

NATIONAL CORRUGATED STEEL PIPE ASSOCIATION
1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174
(202) 452 -1700 – Fax (202) 833-3636

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.
### Load Rating and Structural Evaluation of In-Service, Corrugated Steel Structures

**RED FLAG ITEMS:**

- **Steel Structural plate** has not always been 6” x 2” corrugation, changing the mechanical properties. (3 total changes)

- **Unsymmetrical Structures > 5% defection**
  \[
  \text{Span} = 2 \times \max \ R_t
  \]

- **Flexible Buried Culverts** by nature, move and change shape. Monitoring is essential.

- If mid-ordinate deflections become excessive, \( T_{\text{cap}} \) may = Moment capacity \( M_{\text{cap}} \).

- **Load rating procedure may pass** but structure in danger of failing if mid-ordinate deflections >15% & increasing.

- **Structural Plate Structures can use** a combination of gages in wall. Proper representation in rating is critical.

- **Section properties must be properly adjusted** for wall / bolt damage common in distorted structures.

- **Engineering knowledge and judgment is critical** in proper conclusions.

---

**NCSPA Design Data Sheet No. 19**

### Load Rating And Structural Evaluation of In-Service, Corrugated Steel Structures

- Steel Structural plate has not always been 6” x 2” corrugation, changing the mechanical properties. (3 total changes)

- Unsymmetrical Structures > 5% defection
  \[
  \text{Span} = 2 \times \max \ R_t
  \]

- Flexible Buried Culverts by nature, move and change shape. Monitoring is essential.

- If mid-ordinate deflections become excessive, \( T_{\text{cap}} \) may = Moment capacity \( M_{\text{cap}} \).

- Load rating procedure may pass but structure in danger of failing if mid-ordinate deflections >15% & increasing.

- Structural Plate Structures can use a combination of gages in wall. Proper representation in rating is critical.

- Section properties must be properly adjusted for wall / bolt damage common in distorted structures.

- Engineering knowledge and judgment is critical in proper conclusions.

---

**June 1995**

**NATIONAL CORRUGATED STEEL PIPE ASSOCIATION**

1255 Twenty-Third St., NW – Ste 850 – Washington DC 20037-1174
(202) 452 -1700 – Fax (202) 833-3636

Design Data Sheets are for guidance only. They require an experienced P.E. for proper application.
Field Inspection, Evaluation and Load Rating of Installed Corrugated Metal Culvert Structures

Ohio Transportation Engineering Conference 2012

October 31, 2012

Mitch Hardert
Chief Engineer – CBC Engineers

Jim Noll
Director Engineering Services – CONTECH

Joe Dennis
Director Business Development – CBC Engineers