

# Steel Bridges and Resilience: Engineering the Future of Infrastructure



Presented by the **Short Span Steel Bridge Alliance (SSSBA)** and the **American Galvanizers Association (AGA)**

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Presenter Information, Event Name & Date

[galvanizeit.org](http://galvanizeit.org)

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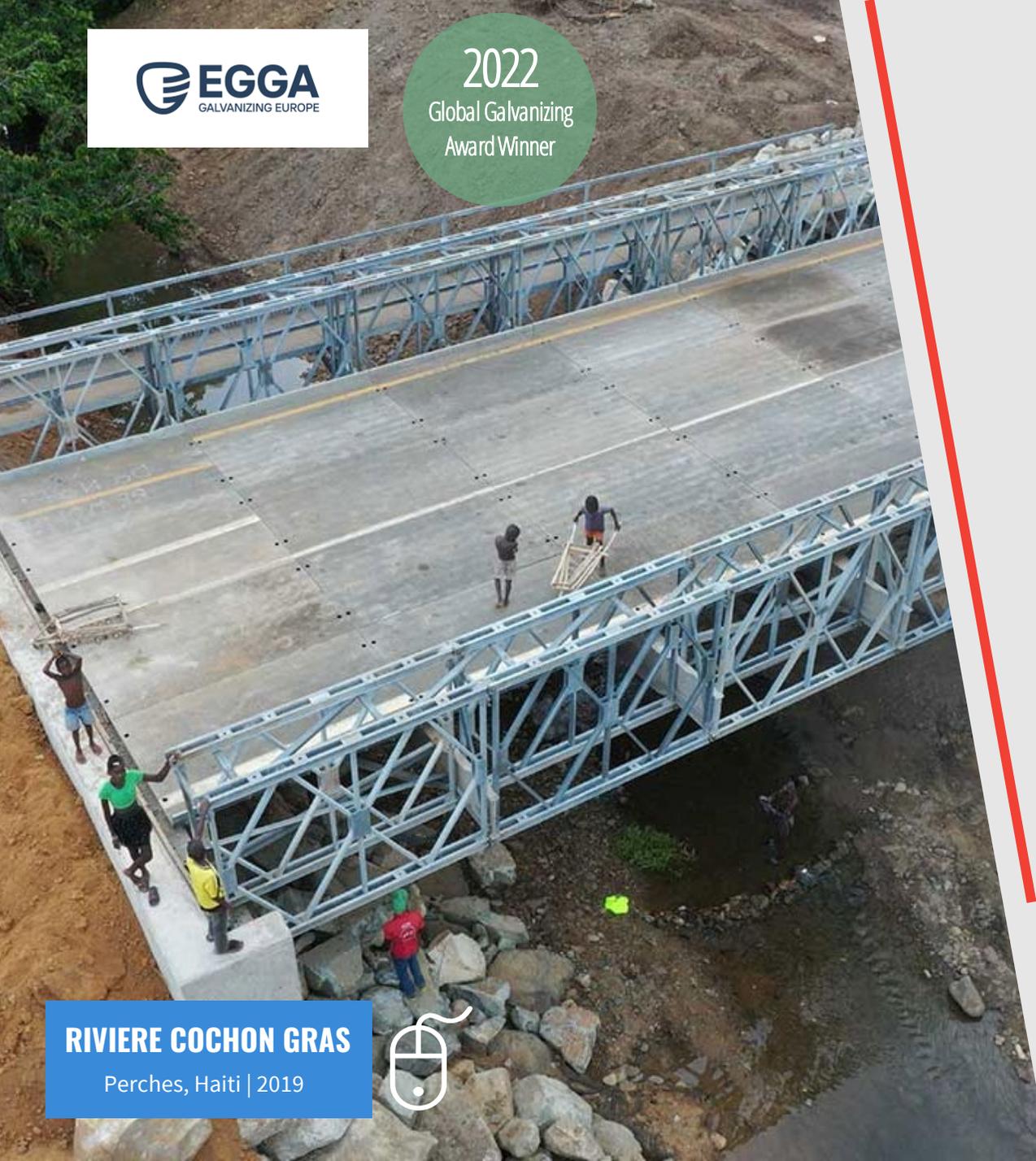


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# Purpose of the Seminar

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To build more resilient bridges, the future must start today. With innovative materials, designs, and protection systems now available, the American steel and galvanizing industry is poised to deliver bridges that endure well into the next century—and beyond. The Short Span Steel Bridge Alliance (SSSBA) and the American Galvanizers Association (AGA) have developed free, essential resources to streamline steel bridge design and ensure long-term performance with a 100-year service life



**RIVIERE COCHON GRAS**

Perches, Haiti | 2019



# Learning Objectives

## Upon seminar completion, you will be able to:

- Innovative new bridge systems that have life expectancy of 100+ years.
- Learn about strength and durability of steel bridges to resist structural damage and quickly rehabilitate & strengthen a steel bridge, while keeping the bridge in service with minimal traffic disruption.
- Recognize the sustainable aspects of durability systems by analyzing the environmental, social and economic impacts of its use from production through end-of-life.
- Identify reasons specifiers choose corrosion protection systems based on durability, availability, versatility, sustainability, and aesthetics

[galvanizeit.org](https://galvanizeit.org)

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FORT WINGATE BRIDGE REPLACEMENT

Gallup, NM | 2022

# About the American Galvanizers Association (AGA)

Non-profit trade organization established in 1933



## Technical

The AGA provides technical support on the performance, design, inspection and specification of HDG steel

## Marketing

The AGA provides its members with sales & marketing support and serves as the unified voice of the industry

## Specifiers

The AGA is a free resource to North American specifiers and provides guidance on specifying HDG steel

[galvanizeit.org](http://galvanizeit.org)

# HDG STEEL

RELIABLE | RESILIENT | RECYCLABLE

## MIRA GUT BRIDGE

Cape Breton, Nova Scotia | 2023

536 tons – The entire superstructure is galvanized. The asphalt on the bridge surface is the only non HDG.





## RELIABLE

- Readily available
- Cost-effective
- Accelerated construction schedules.



## Top 10 Reasons to Use Structural Steel



## RECYCLABLE

- Most recycled material in the world
- High reclamation rates
- Cradle-to-cradle material



## RESILIENT

- High strength to weight ratio
- Adaptable (future expansion)
- Design freedom w/ aesthetic advantages.





**CANDELABRA TOWER**  
Miami, FL | 2009



# Long Lasting Corrosion Protection

3 levels of  
corrosion  
protection in  
one coating  
system

1

## **BARRIER PROTECTION**

Barrier protection resists corrosion by isolating steel from the environment

2

## **CATHODIC PROTECTION**

Zinc is anodic to steel and will sacrificially corrode to protect the underlying steel until all the surrounding zinc is consumed

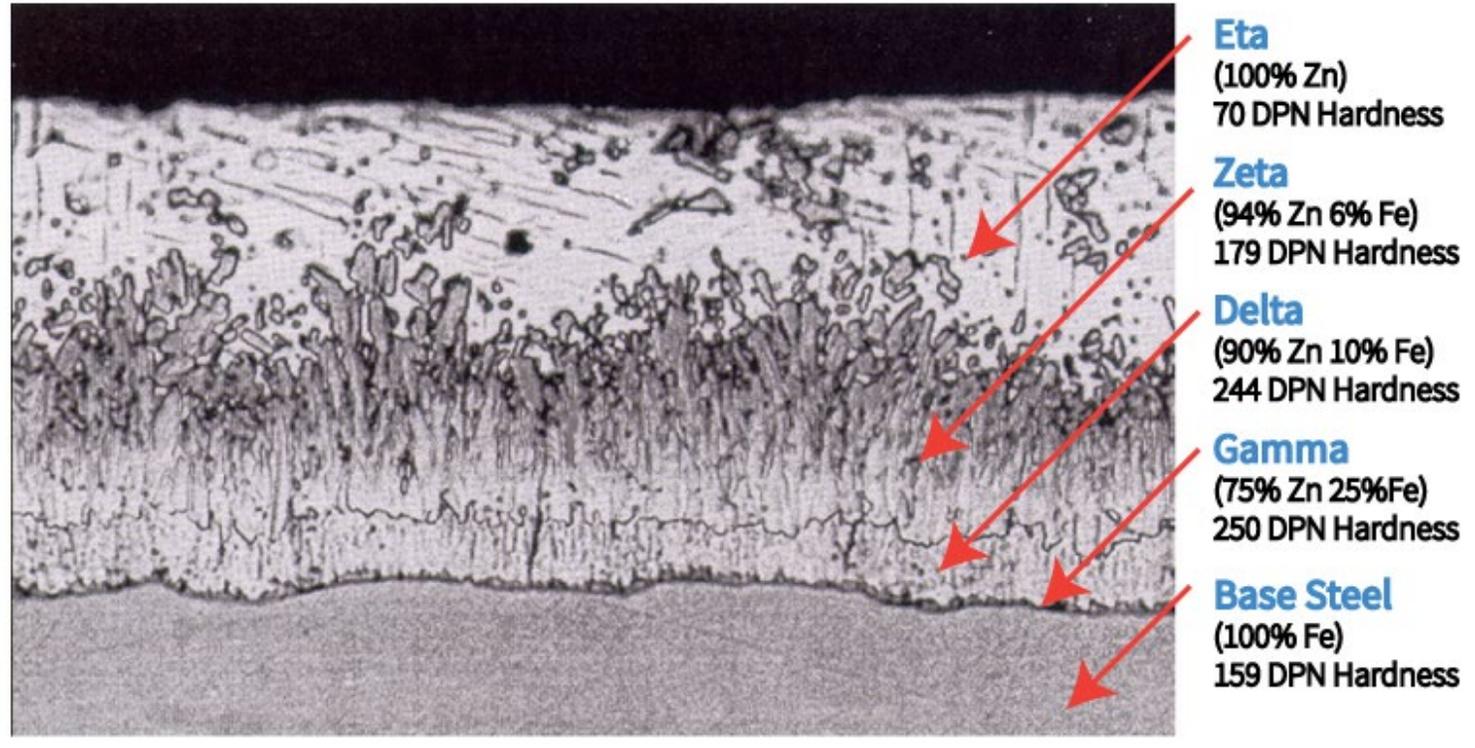
3

## **ZINC PATINA**

Zinc patina develops naturally as the hot-dip galvanized coating weathers slowing the overall corrosion rate

# Durability: Abrasion Resistance

Photomicrograph showing cross-section of hot-dip galvanized coating



- Bond strength: 3,600 psi
- Metallurgical bond
- Intermetallic (Zn-Fe) layers harder than the base steel

\*Note: DPN = Diamond Pyramid Number = Vickers Hardness

# AGA TOOLS & RESOURCES

ESSENTIAL RESOURCES FOR DESIGNING HOT-DIP GALVANIZED BRIDGES

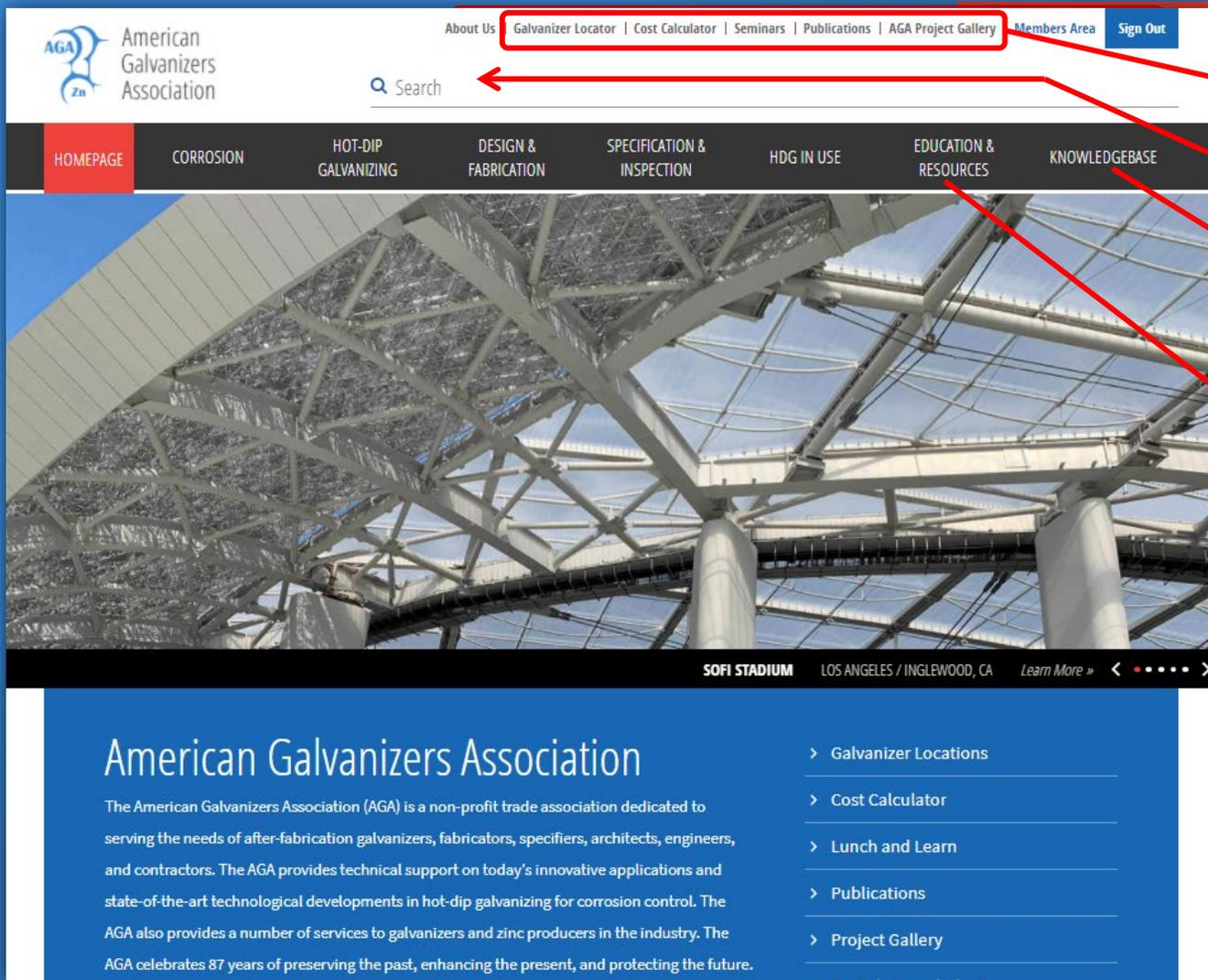
## OGDENSBURG-PRESCOTT BRIDGE REHAB

Ogdensburg, NY | 2021

442 tons – Main span bridge  
decking, structural steel floor  
beams and stingers



# Website - Galvanizeit.org



Tools & AGA Resources

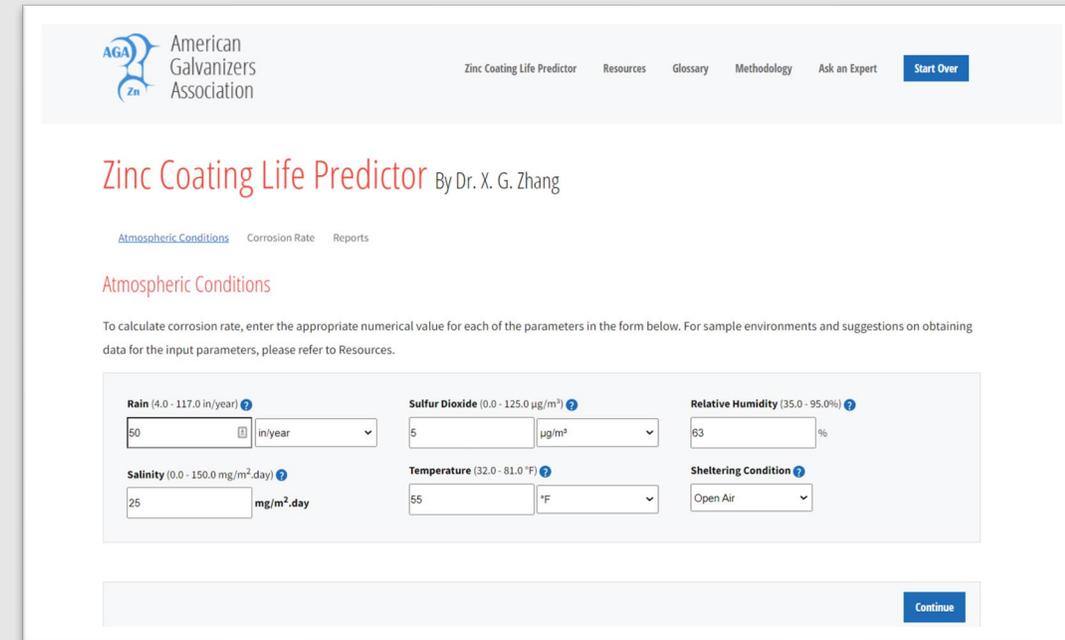
Robust Search Function

Knowledgebase

Education & Resources

# Zinc Coating Life Predictor

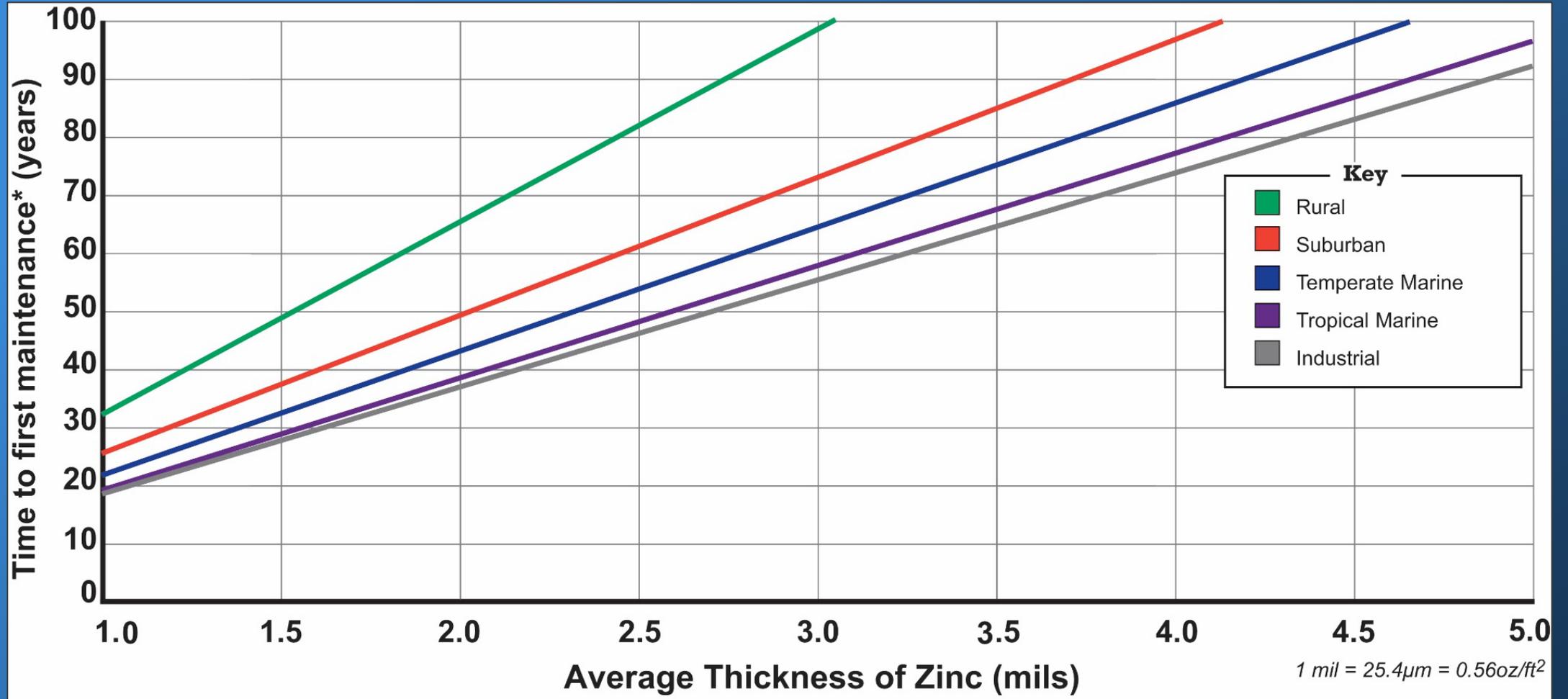
- Estimate the corrosion rate of zinc (galvanized) in various environments
  - Statistical Methods
  - Neural Network Technology
  - Extensive Worldwide Corrosion Database
- Users Guide w/ Links to Collect Local Data
  - <https://galvanizeit.org/knowledgebase/article/the-zinc-coating-life-predictor>
- Used to develop our Time-to-First Maintenance Chart
- **ZCLP.galvanizeit.org**



The screenshot shows the web application interface for the Zinc Coating Life Predictor. At the top, there is a navigation bar with the AGA American Galvanizers Association logo on the left and links for 'Zinc Coating Life Predictor', 'Resources', 'Glossary', 'Methodology', 'Ask an Expert', and a 'Start Over' button on the right. Below the navigation bar, the title 'Zinc Coating Life Predictor' is displayed in red, followed by 'By Dr. X. G. Zhang'. Underneath, there are links for 'Atmospheric Conditions', 'Corrosion Rate', and 'Reports'. The main section is titled 'Atmospheric Conditions' and contains a text box with instructions: 'To calculate corrosion rate, enter the appropriate numerical value for each of the parameters in the form below. For sample environments and suggestions on obtaining data for the input parameters, please refer to Resources.' Below this is a form with six input fields arranged in two rows and three columns. The first row contains 'Rain (4.0 - 117.0 in/year)' with a value of 50 and unit 'in/year', 'Sulfur Dioxide (0.0 - 125.0 µg/m³)' with a value of 5 and unit 'µg/m³', and 'Relative Humidity (35.0 - 95.0%)' with a value of 83 and unit '%'. The second row contains 'Salinity (0.0 - 150.0 mg/m³.day)' with a value of 25 and unit 'mg/m³.day', 'Temperature (32.0 - 81.0 °F)' with a value of 55 and unit '°F', and 'Sheltering Condition' with a value of 'Open Air'. A 'Continue' button is located at the bottom right of the form.



# Time to First Maintenance Chart



\*Time to first maintenance is defined as the time to 5% rusting of the steel surface.

1 mil = 25.4µm = 0.56oz/ft<sup>2</sup>

# Soil Charts

## Evaluate Chloride Concentration

> 20 PPM use Charts 1 & 2

- Evaluate Moisture Content
- Evaluate pH

< 20 PPM use charts 3 & 4

- Evaluate pH
- Evaluate Moisture Content

\*NOTE: Service life is defined as the time to necessary part replacement (total zinc consumption + 25%)



Soil Chart  
(PDF)

### High Chlorides >20 PPM

CHART 1

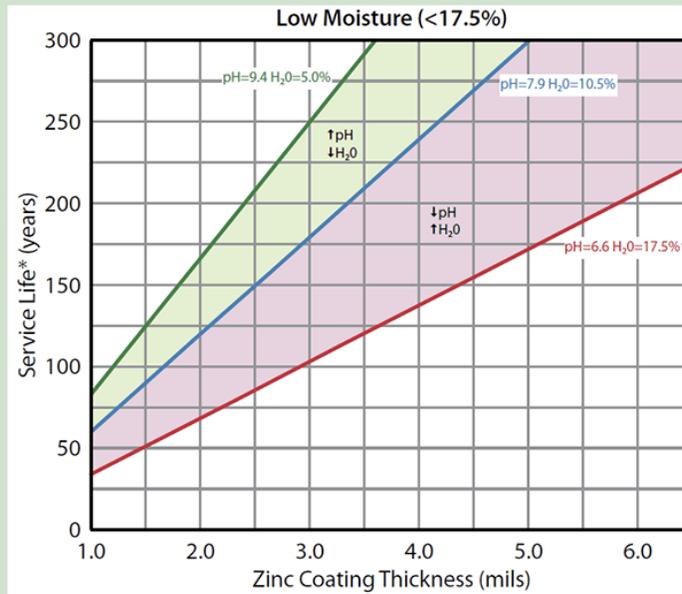
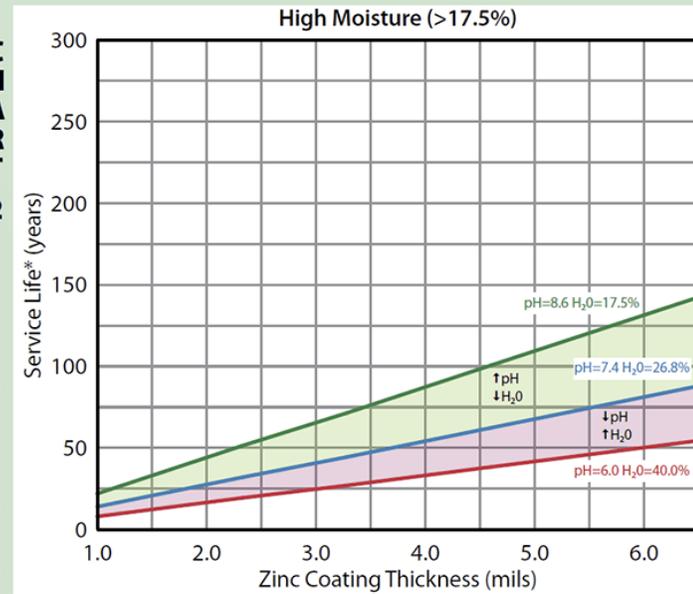


CHART 2



### Low Chlorides <20 PPM

CHART 3

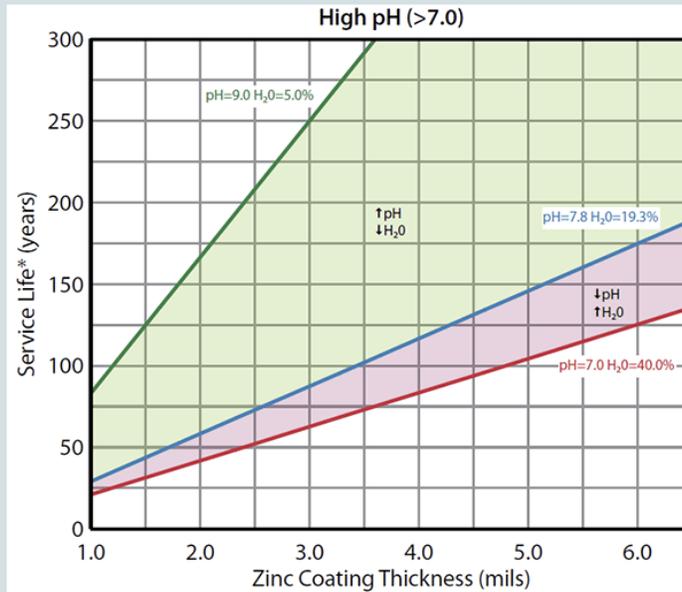
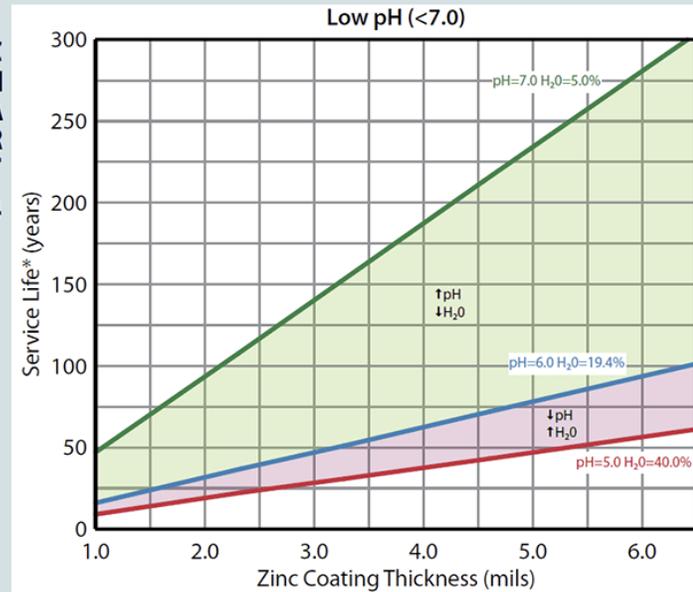


CHART 4



\* Service life is defined as the time to necessary part replacement or underground maintenance.

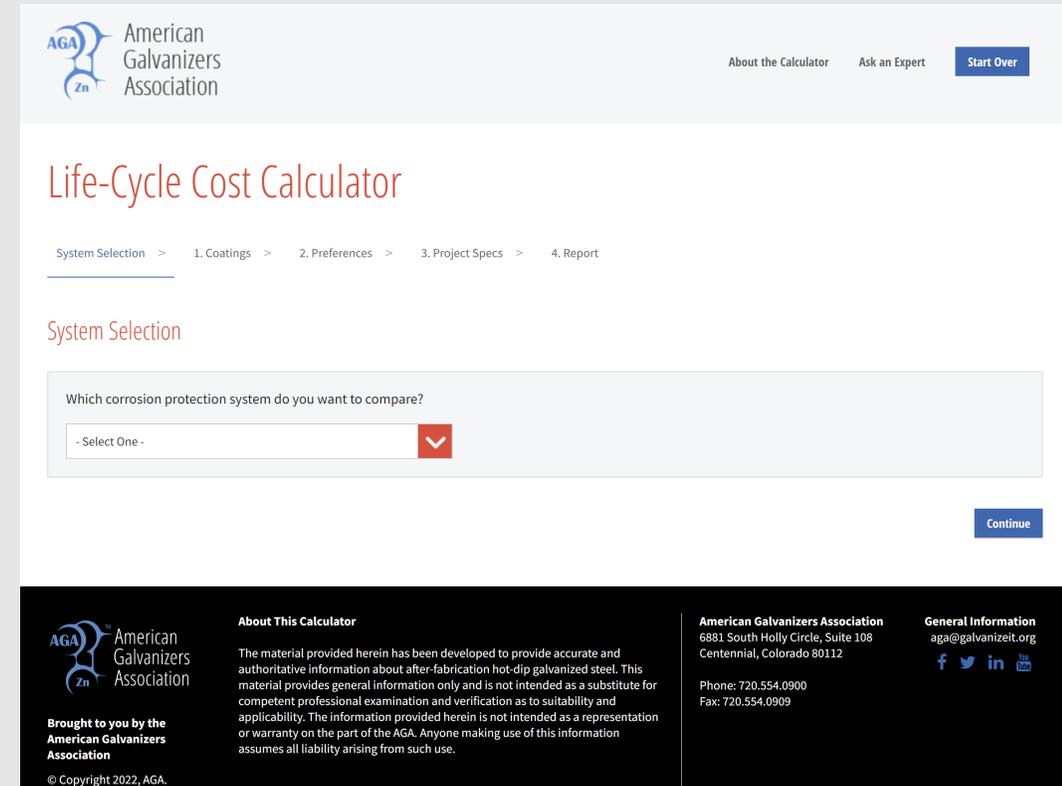
1 mil = 25.4 μm = 0.56 oz/ft<sup>2</sup>

galvanizeit.org

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# Life-Cycle Cost Calculator

- Life-Cycle Cost Savings
  - Total cost throughout project life
  - Includes maintenance costs and time value of money (interest/inflation)
  - Often HDG initial cost IS life-cycle cost
- Life-Cycle Cost Calculator to ASTM A1068



The screenshot shows the web interface for the Life-Cycle Cost Calculator. At the top left is the American Galvanizers Association logo. To the right are links for 'About the Calculator', 'Ask an Expert', and a 'Start Over' button. The main heading is 'Life-Cycle Cost Calculator'. Below it is a breadcrumb trail: 'System Selection > 1. Coatings > 2. Preferences > 3. Project Specs > 4. Report'. The current page is 'System Selection', which contains a dropdown menu with the text 'Which corrosion protection system do you want to compare?' and the option '- Select One -'. A 'Continue' button is located at the bottom right of the form area. The footer contains the AGA logo, a disclaimer under 'About This Calculator', contact information for the American Galvanizers Association, and social media icons under 'General Information'. A red mouse cursor icon is positioned at the bottom center of the page, pointing towards the calculator interface.

# LCCC: Inputs

**PROJECT SIZE**  
Enter amount of steel to be coated.

ft<sup>2</sup>  tons

**EXPECTED LIFE-SPAN**  
Amount of time before this structure is no longer maintained or in use.

Years

**STRUCTURE TYPE**  
Specify the size and/or complexity of the structure.

- Select One - 

**MEMBER TYPE**  
Select the project's structural makeup.

Typical mix size/shapes  
250 ft<sup>2</sup> / ton

Large Structural  
100 ft<sup>2</sup> / ton

Medium Structural  
200 ft<sup>2</sup> / ton

Light Structural  
400 ft<sup>2</sup> / ton

Light Trusses  
500 ft<sup>2</sup> / ton

**SERVICE LIFE ENVIRONMENT**  
Select the environment that represents your project's location.

Rural  
Mild/Low Corrosion (C2)

Industrial  
Moderate/Medium Corrosion (C3)

Heavy Industrial  
Severe/Very High Atmospheric Corrosion (C5-I)

Seacoast  
Very high Atmospheric Corrosion (C5-M)

# LCCC: Reports

## Life-Cycle Cost Calculator

System Selection > 1. Coatings > 2. Preferences > 3. Project Specs > 4. Report

### Cost-Comparison Report

Review and customize before printing

#### Cost-Comparison Report

The cost of galvanizing vs. a paint system

**Cost Comparison**  
HDG vs. IOZ/Epoxy/Polyurethane

	HDG	Paint System
<b>Initial Cost</b>		
Per ft <sup>2</sup>	\$2.16	\$4.98
Total	\$108,000.00	\$249,050.00
<b>Life-Cycle Cost</b>		
Per ft <sup>2</sup>	\$2.16	\$31.39
Total	\$108,000.00	\$1,569,500.00
<b>AEAC</b>		
Per ft <sup>2</sup>	\$0.07	\$1.08

For this project...  
**HDG Life-Cycle Cost Savings: 93%**

**DETAILED COST COMPARISON**  
HDG vs. IOZ/Epoxy/Polyurethane

Cost Of Galvanizing	Today's Cost	Net Future Value	Net Present Value
Original Galvanizing	\$2.16	\$2.16	\$2.16
<b>Total Price / ft<sup>2</sup></b>	<b>\$2.16</b>	<b>\$2.16</b>	<b>\$2.16</b>

Cost Of Paint System	Today's Cost	Net Future Value	Net Present Value
Original Painting	\$4.98	\$4.98	\$4.98
Touch-Up - Year 21	\$2.49	\$5.68	\$3.05
Maint. Repaint - Year 31	\$4.48	\$15.42	\$6.08
Full Repaint - Year 42	\$8.47	\$43.97	\$12.71
Touch-Up - Year 63	\$2.49	\$29.47	\$4.58
<b>Total Price / ft<sup>2</sup></b>	<b>\$22.91</b>	<b>\$99.52</b>	<b>\$31.39</b>

**PRINT PREVIEW**  
CUSTOMIZE REPORT

Project Name

Subtitle

Your Company's Name

Address

City, State & Zip

Your Name

Title

Tel

Email

## Bridge & Highway

Hot-dip galvanized steel is the backbone of North American bridges and highway elements. Galvanized steel is used in the superstructure, substructure, and decking (reinforcing steel) of bridges, as well as in mechanically stabilized earth, guardrail, light posts, and sign structures along the roadways. Federal, state, county, and local officials must invest taxpayers dollars responsibly to achieve 100-year bridge designs, and utilizing hot-dip galvanizing throughout the infrastructure is a great way to protect this investment for current and future generations.

LEARN MORE



Passerelles Beauport (Pedestrian Bridges)

BEAUPORT, QC CANADA | 2020



Gerald Desmond Bridge

PORT OF LONG BEACH, CA UNITED STATES | 2020



Old City Park Walking Bridge

GREENWOOD, IN UNITED STATES | 2020



Pymont Road Bridge Rehab

LEWISBURG, OH UNITED STATES | 2020



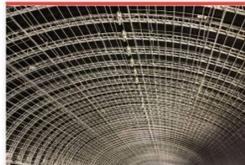
Walt Whitman Bridge Drainage System

PHILADELPHIA, PA UNITED STATES | 2020



Highway 410 Mississippi River Bridges

LENNOXVILLE, QC CANADA | 2020



Park Avenue Tunnel

NEW YORK, NY UNITED STATES | 2020



Fourteen Mile Bridge

EAST LYNN, WV UNITED STATES | 2020

# Excellence in Hot-Dip Galvanizing Awards

- Large Database of HDG Projects
- Over 2,000 HDG Projects
- Filter by
  - Sector, Year, Location, Environment, Galvanizer and Reason for Galvanizing
- Annual program recognizing innovative uses of hot-dip galvanized steel
- Submit your best HDG projects online at: <http://galvanizeit.org/EASubmissions>



# Inspection

- Steel inspected after galvanizing to verify conformance to specs
- Visual inspection with naked eye
- Coating thickness checked by magnetic thickness gauge
- Inspection of HDG Steel Products Guide
- [AGA Online Inspection Course](#)
- Download free Inspection App
  - [galvanizeit.org/mobile](https://galvanizeit.org/mobile)



[galvanizeit.org](https://galvanizeit.org)

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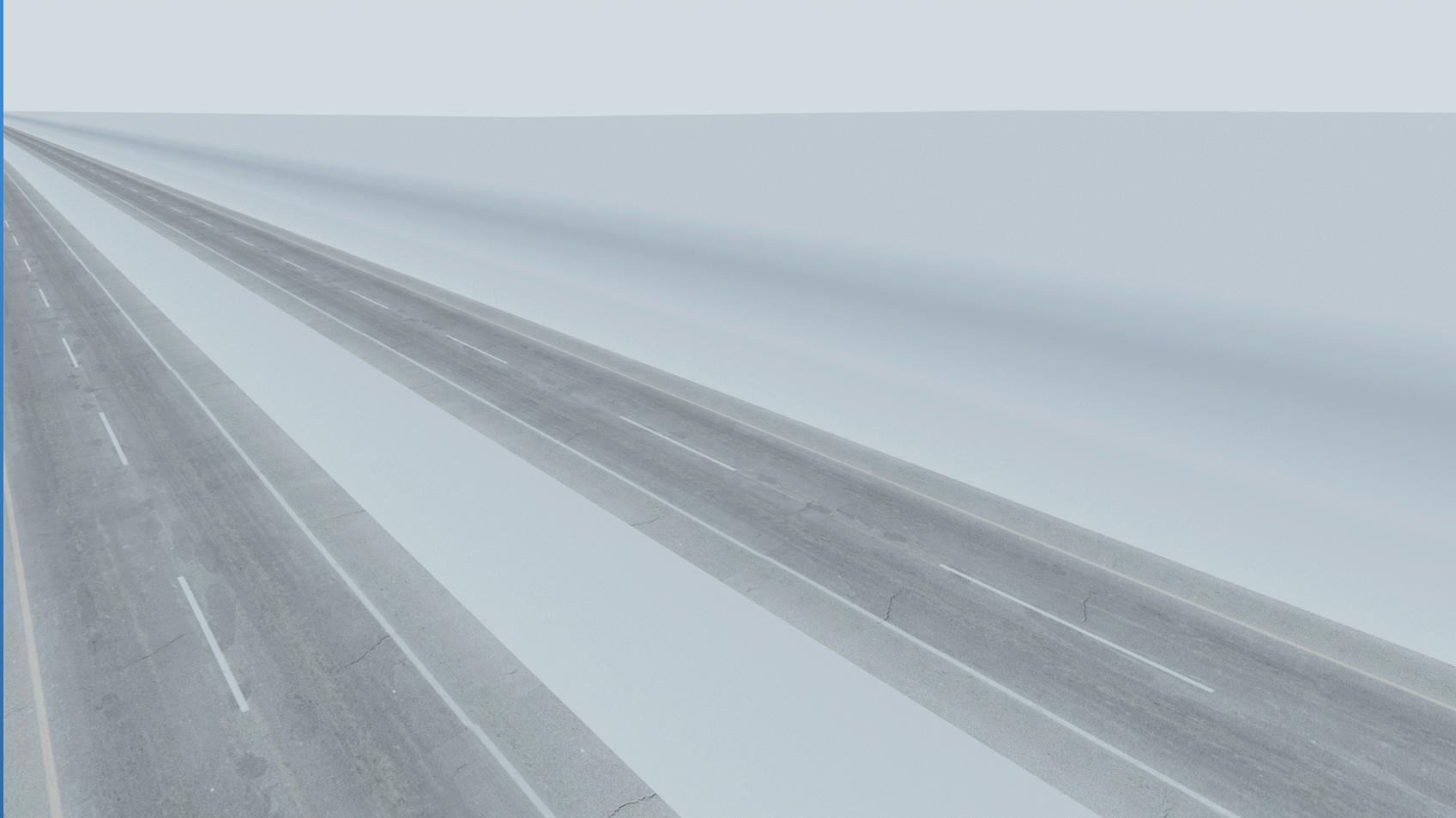


 Inspection of HDG Products Guide (PDF)



# HDG Components in Bridges & Highways

[markets.galvanizeit.org](https://markets.galvanizeit.org)

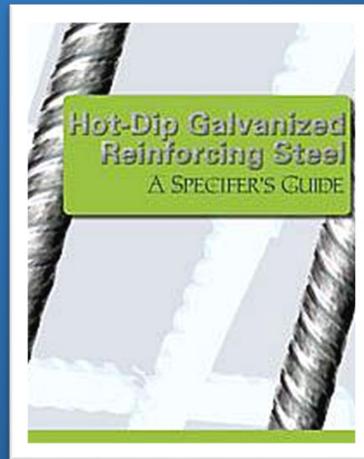
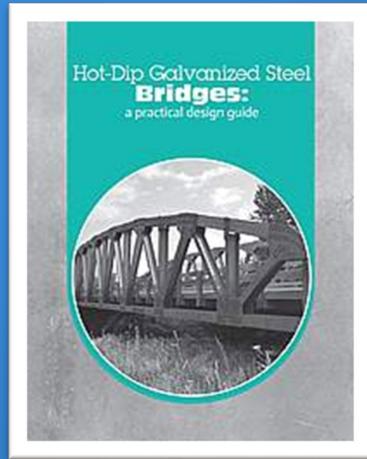


[galvanizeit.org](https://galvanizeit.org)

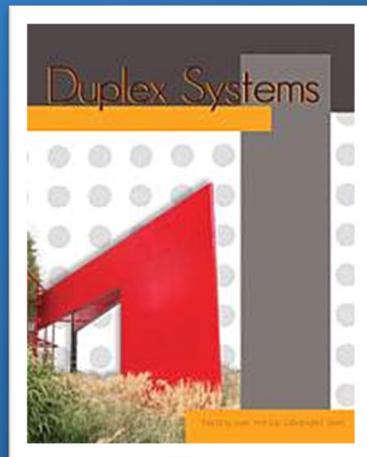
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# Publications

More than 40 pubs available | Download free PDFs online



- **Bridge Specific Publications**
- **Hot-Dip Galvanized Steel Bridges: A Practical Design Guide**
- **Hot-Dip Galvanized Reinforcing Steel: A Specifier's Guide**
- **Duplex Systems: Painting over HDG**
- **Inspection of Hot-Dip Galvanized Steel Products**
- **Hot-Dip Galvanizing for Sustainable Design**



[galvanizeit.org](http://galvanizeit.org)

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# GalvanizedRebar.com

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- Dedicated website for galvanized rebar information.
  - Performance, Mechanical Properties, Field Handling
  - Standards
  - Case Studies
  - Publications
  - FAQs



[galvanizeit.org](https://galvanizeit.org)

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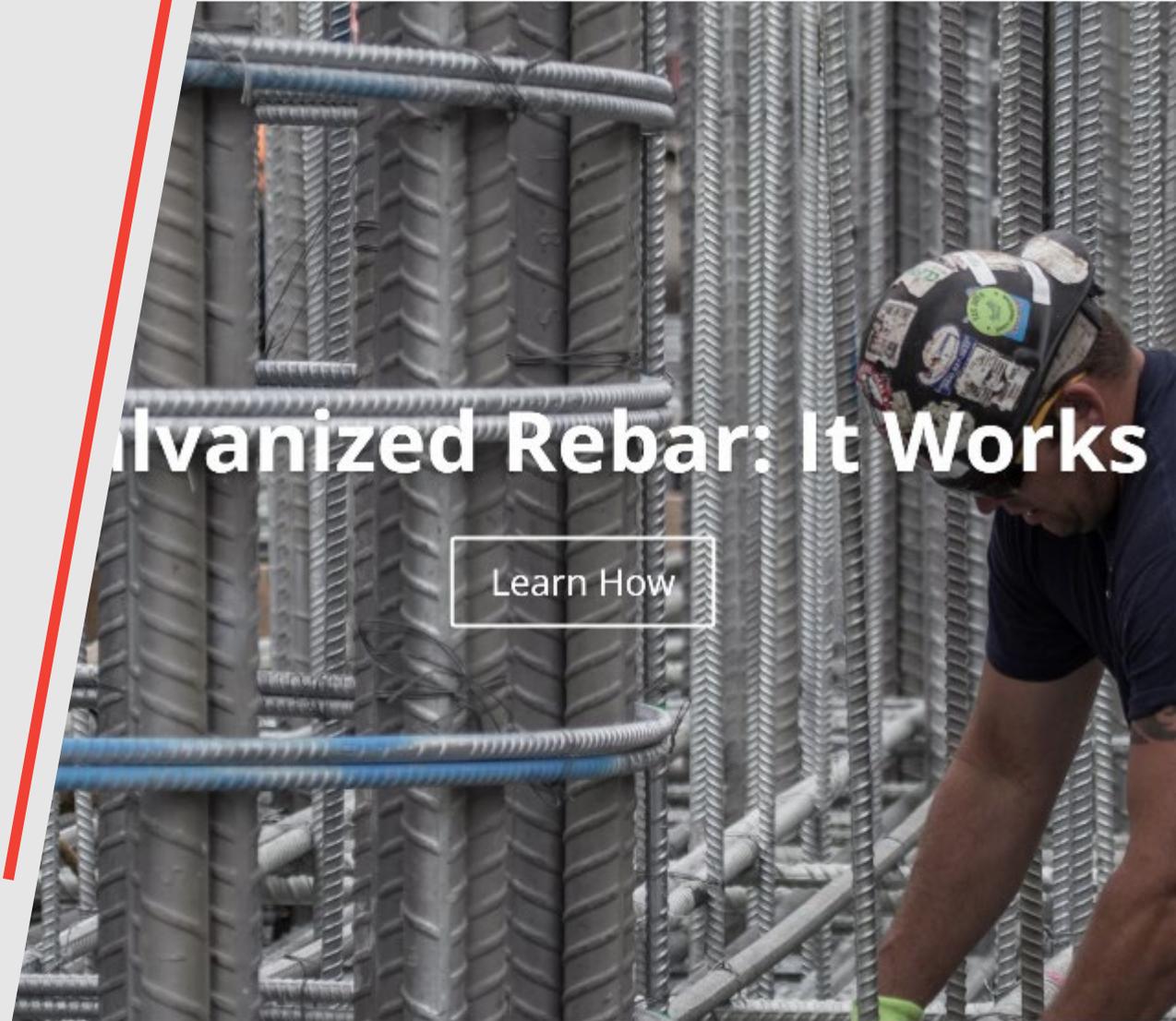
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## Galvanized Rebar: It Works

Learn How

# Dr. Galv™ Knowledgebase

The screenshot shows the website for the American Galvanizers Association's Dr. Galv Knowledgebase. The top navigation bar includes links for About Us, Galvanizer Locator, Cost Calculator, Seminars, Publications, AGA Project Gallery, and Members Area, along with Login and Sign Up buttons. A search bar is located below the navigation. The main menu features categories: HOMEPAGE, CORROSION, HOT-DIP GALVANIZING, DESIGN & FABRICATION, SPECIFICATION & INSPECTION, HDG IN USE, EDUCATION & RESOURCES, and KNOWLEDGEBASE (highlighted in red). Below the menu, there are social media icons for Facebook, Twitter, LinkedIn, and YouTube. The main content area is titled 'Dr. Galv KnowledgeBase' and features a sidebar with a list of topics: Appearance, ASTM & Other Specifications, Coating Thickness, Duplex Systems, Fasteners, HDG Process, Health, Safety & Environment, Inspection, and Performance. The main content area displays 'Featured Questions' with three items: 'HDG Corrosion Rates for' (with a line graph showing 'Time to First Maintenance' vs 'Average Thickness of Zinc Spillage'), 'Incoming Parts' (with an image of a worker in a factory), and 'Customer Requests for' (with an image of stacked metal coils).

- More than 400 short form Q&A articles
  - Organized by category
  - Visible using search function
  - Some are member protected
    - HDG Process
    - Environmental Health & Safety
- Designed to answer specific FAQs about anything galvanizing.



# Bridge Size Considerations

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- Galvanizing limited by the size of the kettle
  - Avg. in North America 40 ft, many 50-60 ft
- Modular Design
  - Design in modular or sub-units to fit
  - Connect after galvanizing (bolting, welding)
- Combination: Metallizing & HDG
- Progressive Dipping



Bridges of Stark County (Canton, OH)  
HDG in 1975

# Progressive Dipping

→ Depends on:

→ Kettle dimensions

→ Part dimensions

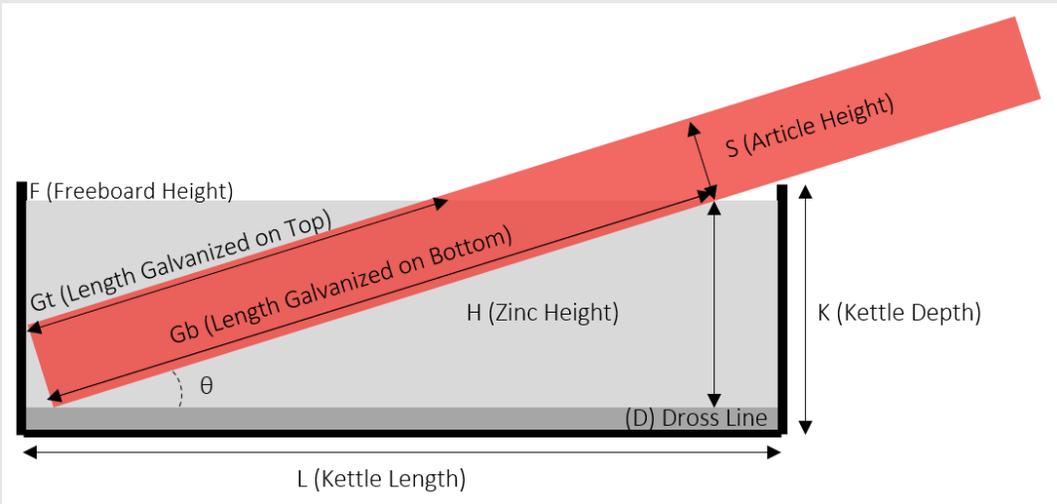
→ Material handling capabilities  
(layout, cranes)

→ Managing Expectations:

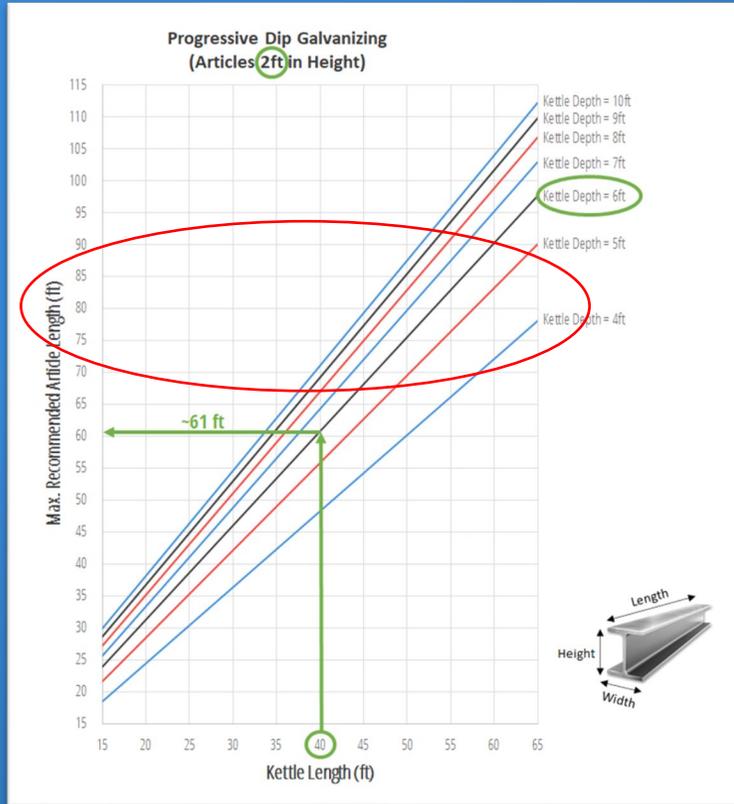
→ Overlap line appearance and roughness

→ Uneven heating

→ Increased susceptibility to warpage



# AGA Resources for Progressive Dipping



Galvanizer Locator  
(sort by Kettle Size)

## Search Results:

Address/Zip State/Province Company Name

Search Locations by Address/Zip

77584 100 miles SEARCH

*This listing only shows the dimensions of the galvanizer's kettle (bath), and does not indicate the maximum material size that can be galvanized. Please contact the galvanizer for more information on capacity limits.*

### Galvanizers:

Filter by:

Length  0-24  25-34  35-44  45-54  55+

Width  0-4  5-7  8+

Depth  0-5  6-7  8-9  10+

---

**Valmont Coatings - United Galvanizing**

6123 Cunningham Rd Houston, TX 77041 United States  
Phone: (713) 466-4161 Website

Kettle(s) (L x W x D):  
61' x 7'3" x 7'3"  
42' x 5' x 6'

[View Portfolio](#)

---

**AZZ Galvanizing - Houston West**

9103 fairbanks, N. Houston Houston, TX 77064  
Phone: (832) 467-3772 Website

Kettle(s) (L x W x D):  
62' x 8' x 10'

Progressive Dip Charts

galvanizeit.org

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**AGA** American Galvanizers Association  
Protecting Steel for a Sustainable Future

## Progressive Dip Calculator

**USER INPUTS**

**Enter Kettle Dimensions:**

K (Kettle Depth)	72 inches
L (Kettle Length)	600 inches
W (Kettle Width)	60 inches

**Enter Article Dimensions:**

(S) Height	34 inches
Length	780 inches
Width	16 inches

**Enter Properties of Zinc Height:**

Dross Line Height	8 inches
Freeboard Height	4 inches

If unknown: use dross height = 8 in. and freeboard = 4 in.

**Allowable Angles in the Bath:**

θ minimum	6.1 °
θ maximum	6.3 °

**Can This Article be Fully Galvanized?** YES ✓

**Article Orientation:** |

**Dip Method:** Progressive Dip

**Diagram Labels:**

- F (Freeboard Height)
- Gt (Length Galvanized on Top) = 245in
- Gb (Length Galvanized on Bottom) = 562in
- H (Zinc Height) = 60in
- K (Kettle Depth) = 72in
- S (Article Height) = 34in
- L (Kettle Length) = 600in
- D (Dross Line)
- θ = 6.1°

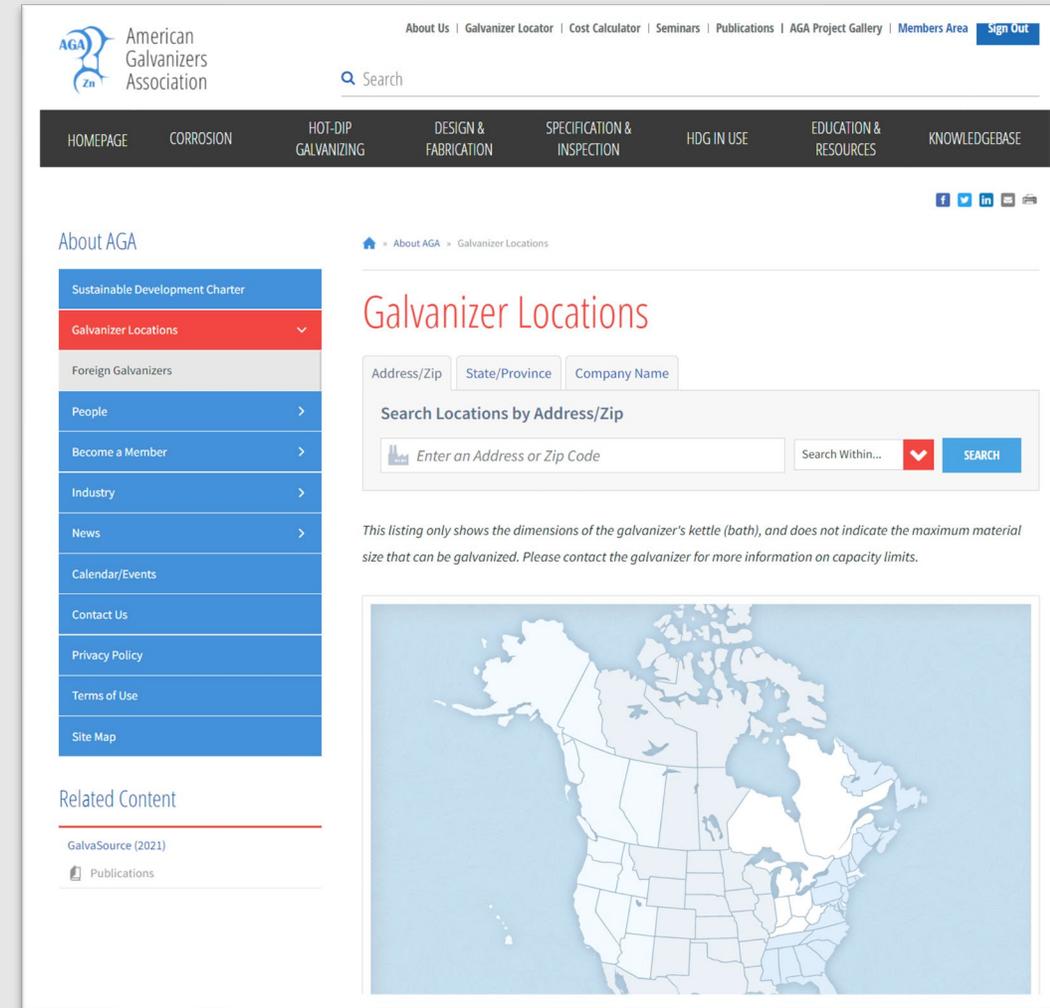
**Overlap Diagram:**

- Gt (Length Galvanized on Top)
- Gb (Length Galvanized on Bottom)
- OVERLAP LINE
- Gt + Gb (Max. Progressive Dip Length) = 807.1in

Progressive Dip Calculator

# Galvanizer Locator

- Members of the AGA encompass more than 95% of all hot-dip galvanizing capacity in North America.
- Approximately 70 companies and 170 locations
- Search by Address, State/Province or Company Name
- Includes Kettle Sizes
- Includes Project Gallery links



The screenshot displays the American Galvanizers Association (AGA) website. The header includes the AGA logo and navigation links: About Us, Galvanizer Locator, Cost Calculator, Seminars, Publications, AGA Project Gallery, Members Area, and Sign Out. A search bar is located below the header. The main navigation menu features: HOMEPAGE, CORROSION, HOT-DIP GALVANIZING, DESIGN & FABRICATION, SPECIFICATION & INSPECTION, HDG IN USE, EDUCATION & RESOURCES, and KNOWLEDGEBASE. The page title is "Galvanizer Locations". A search form is present with fields for "Address/Zip", "State/Province", and "Company Name", and a "SEARCH" button. Below the search form, a map of North America is shown. A note states: "This listing only shows the dimensions of the galvanizer's kettle (bath), and does not indicate the maximum material size that can be galvanized. Please contact the galvanizer for more information on capacity limits." A red mouse cursor icon is visible on the left side of the page.



# QUESTIONS?

[GALVANIZEIT.ORG](https://www.galvanizeit.org)



American Galvanizers Association  
*Protecting Steel for a Sustainable Future*

## OFFICE



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[@AGAGalvanizeit](https://www.youtube.com/AGAGalvanizeit)



# **STEEL BRIDGES & RESILIENCE: ENGINEERING THE FUTURE OF INFRASTRUCTURE**

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United for Infrastructure

May 15, 2025

Michael Barker, PE  
University of Wyoming  
Director of Education, SSSBA



# Short Span Steel Bridge Alliance

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A group of **bridge** and **buried soil structure** industry leaders who have joined together to provide **educational information** on the design and construction of short span steel bridges in installations up to **140 feet in length**.

# Membership



# Short Span Steel Bridge Solutions

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## Buried Bridges



## Rolled Beam & Plate Girders



## Press-Brake-Formed Tub Girders



## Truss Bridges



# What Do We Provide?

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- Education
  - Workshops, Webinars, Newsletter
- Technical Resources
  - Standards, best practices, case studies
- Simple Design Tools (eSPAN140)
- Project Assistance
- Find a Supplier
- Networking / SSSBA Semiannual Meeting



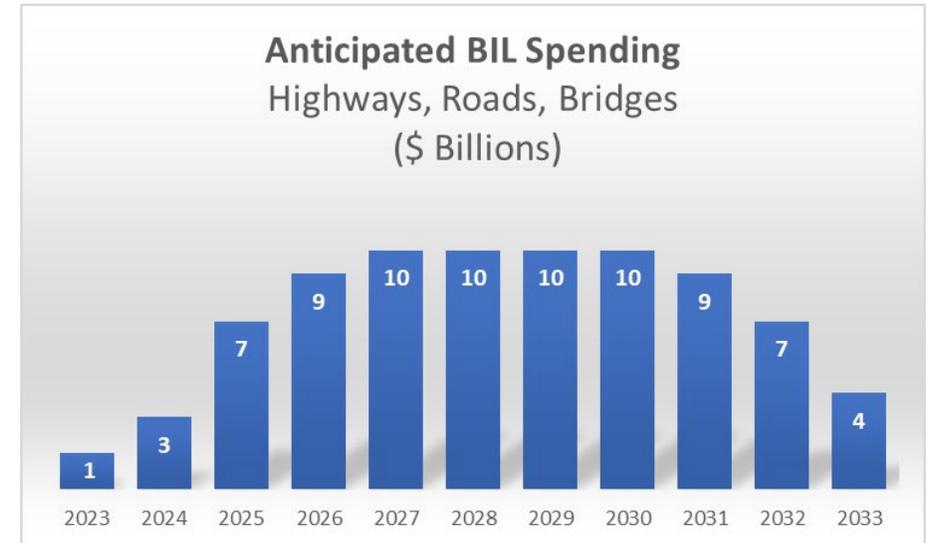
# Resiliency – Infrastructure

- **Bipartisan Infrastructure Law**

- \$39.5 billion over 5 years to repair or replace as many as 15,000 bridges
- Minimum 15% must be used to build off-system bridges

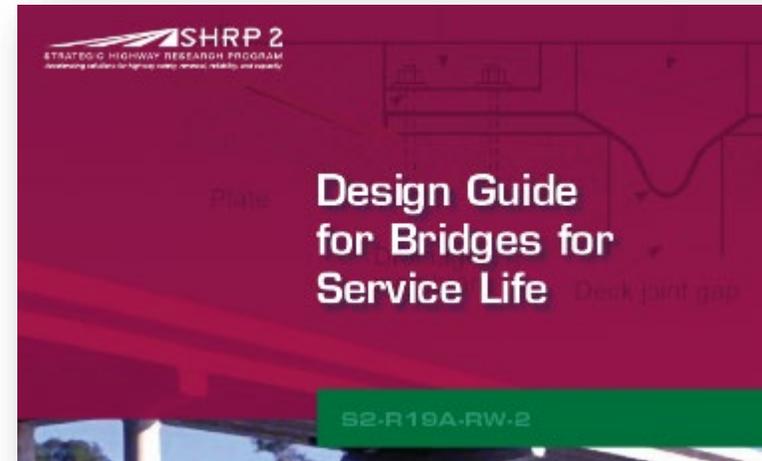
- **PROTECT (\$7.2 billion)**

- BIL establishes the **Promoting Resilient Operations** for Transformative, Efficient, and Cost-Saving Transportation (PROTECT) Formula Program
  - Make surface transportation **more resilient** to natural hazards (support of planning activities, resilience improvements, community resilience and evacuation routes, and at-risk coastal infrastructure).



\* Source: McKinsey Insights

# Design for Service Life and Durability



## Challenge

Because of deterioration, individual bridge components and systems such as bearings, decks, joints, columns, and girders require frequent and costly inspections, maintenance, and repairs that are often difficult to conduct. These activities cause lane closures that create congestion and impact safety for road workers and motorists. Bridge engineers need improved design options so they can deliver bridges that are operational for 100 years or more.

Learn more - <https://www.shortspansteelbridges.org/steel-bridges-beyond-100-years>

# Resiliency

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## What is a Resilient Bridge?

- Service Life & Life Cycle Performance
- Robustness for Unexpected Demands: Seismic, Natural, Man-Made
- Rehabilitation & Strengthening
- Inspectable & Repairable
- Sustainable

But, the Bridge Also Needs to Be Economical

# Initial Costs for Steel & Concrete Bridges

SSSBA Conducted Case Studies:

County & State Bridges

Bids & Actual Costs

Case Studies of County Bridges

Others Not Shown Here

Superstructure	Steel						Concrete				
	061	140	149	152	710	AVG	028	057	069	520	AVG
Bridge Number	061	140	149	152	710	AVG	028	057	069	520	AVG
Year Built	2008	2008	2008	2009	2010	AVG	2009	2010	2011	2006	AVG
Span Length	50	50	40	62	64	53.2	36	36	38	40	37.5
Skew	0	0	0	30	35	13	0	15	20	30	16.25
Cost Summary											
- Labor	\$14,968	\$21,705	\$15,853	\$24,765	\$31,949	\$21,768	\$12,065	\$15,379	\$14,674	\$19,044	\$15,291
- Material	\$56,676	\$53,593	\$46,282	\$92,821	\$69,357	\$63,746	\$51,589	\$54,450	\$50,576	\$46,850	\$50,866
- Rock	\$6,170	\$6,216	\$3,694	\$8,235	\$6,501	\$6,163	\$5,135	\$7,549	\$5,378	\$3,621	\$5,421
- Equipment	\$7,487	\$12,026	\$7,017	\$19,579	\$15,266	\$12,275	\$5,568	\$10,952	\$11,093	\$14,742	\$10,589
- Guardrail	\$4,715	\$7,146	\$3,961	\$7,003	\$7,003	\$5,966	\$4,737	\$4,663	\$5,356	\$3,323	\$4,520
Construction Cost	\$89,616	\$100,686	\$76,807	\$152,403	\$130,076	\$109,918	\$79,094	\$92,993	\$87,077	\$87,580	\$86,686
CONST. COST PER FT <sup>2</sup>	\$74.68	\$83.91	\$80.01	\$102.42	\$84.68	\$86.09	\$91.54	\$107.63	\$95.48	\$91.23	\$96.32

## State Bridge (Designed by eSPAN140)

Kansas Department of Transportation

- Shawnee County
- 112 feet (5 plate girder bridge)
- Competitive bid process (steel vs. concrete)
- DOT used eSPAN140 for preliminary design
- Constructed in summer 2014



1 Steel Bridge Bid  
3 Concrete Bridge Bids

Steel = \$ 1.240 mil

Concrete = \$ 1.243 – 1.425 mil

## NSBA Cost Study

## National Bridge Cost by Beam Subtype (\$/SF)

(#) indicates number of bridges for each beam type

● Minimum ● 25th Percentile ● 75th Percentile ● Maximum

Less Than 100 ft.



## County Bridge (Designed by eSPAN140)

- Boone County, Missouri (Local)
  - High Point Lane Bridge
  - 102 feet (2 lane rural road plate girder bridge)
  - 44" weathering steel plate girders (4 lines)
  - Constructed in summer 2013



## Two MoDOT Bridges Crossing US 63 in Boone County

Concrete P/S: 92 ft – 92 ft				Steel Plate Girder: 98 ft – 98 ft			
Route H (Columbia Airport)				Discovery Parkway (Columbia)			
Using ENR CCI Index Increase of 2.7%/yr For 2017 Concrete = \$ 91.18/ft <sup>2</sup> Steel = \$ 85.58/ft <sup>2</sup>				Total Bridge Cost = \$ 277.21 Total Bridge Cost = \$ 272.54			

"These conclusions come as a surprise to the authors, who assumed that concrete bridges would be more cost-competitive than steel bridges."

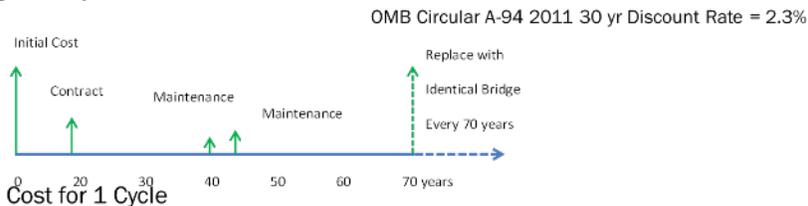
- Mike Digregorio, HDR

# Life Cycle Costs for Steel & Concrete Bridges

## Historical Life Cycle Costs of Steel & Concrete Girder Bridges

Examine Historical Life Service (Performance and Maintenance) and Agency Life Cycle Costs (True Agency Costs for a Bridge) of Steel and Concrete Bridges in Pennsylvania

Example Bridge Life Cycle



OMB Circular A-94 2011. 30 yr Discount Rate = 2.3%

$$PVC = \$143.45 + \$16.63(1.023)^{-19} + \$0.28(1.023)^{-40} + \$0.34(1.023)^{-44} = \$154.49/ft^2$$

Perpetual Present Value Cost = Capitalized Cost

$$PPVC = \$154.49 \left[ \frac{(1 + 0.023)^{70}}{(1 + 0.023)^{70} - 1} \right] = 1.256(\$154.49) = \$193.97/ft^2$$

With Capitalized Costs, Can Compare Bridges Directly



**Introduction**  
Historical Life Cycle Costs of Steel and Concrete Girder Bridges research conducted by Michael Barker, Ph.D., D.E., professor at the University of Wyoming, explores the initial costs, life cycle costs, future costs, and bridge life of 1,584 typical steel and concrete spans bridges in Pennsylvania built between 1960 and 2010.

Dr. Barker frequently meets with county engineers and other bridge design professionals across the U.S. and raises questions on this topic, but there was no research comparing the two materials, so he undertook the project himself. He compiled a database from PennDOT historical data comparing the types of bridges, including concrete precast beams, box girders, and box girder bridges, and steel I-beam and welded plate girders. Results showed steel beams have the lowest average deterioration rate, have the longest average expected life (85 years) offer the lowest average initial and life cycle costs for short bridges, and have lower average future costs compared to initial costs.

**Life Cycle Cost Study**  
The Federal Highway Administration promotes consideration of Life Cycle Costs (LCC) in the design and engineering of bridges. LCC determines the "true cost" of bridge alternatives considering the time value of money. To compare the five types of bridges in the study, historical bridge initial and maintenance costs were converted to present-day dollars using the Perpetual Present Value Cost (PPVC) of bridge alternatives for an equivalent comparison between the bridge types. PPVC is a form of Equivalent Uniform Annual Costs in the present value cost of continuing the bridge into perpetuity. Results of the PennDOT database show all five types of bridges are competitive for initial costs. Future costs, life cycle costs and bridge life, for any given bridge project, any of the five types may result in the lowest life cycle costs. Therefore, owners should consider both steel and concrete alternatives for an individual bridge project.



**Deterioration Rates**  
There are 4,517 bridges in the PennDOT inventory built between 1960 and 2010. They were used to determine the average deterioration rates (to condition rating one year) for the different types of bridges. To avoid if deterioration rate, it was assumed the superstructure condition rating decreased linearly over time. Table 1 presents the average deterioration for each bridge type. Steel beam bridges have the lowest average deterioration rate.

Bridge Type	Number of Bridges	Average Year Built	Average Bridge Life (Years)
Steel Beam	92	1981	85.0
Steel Girder	102	1977	79.0
PVA Box - Reinforced	204	1984	79.0
PVA Box - Spandrel	85	1984	79.0
Box Girder	43	1984	79.0

Table 1: Average Bridge Life

**Bridge Life**  
To determine remaining life for each bridge, it is assumed the bridge will be replaced when the superstructure condition rating reaches 3 given the current condition and the deterioration rate in Table 1. Table 2 presents the average year built and the average bridge life for the different types of bridges in the Life Cycle Cost database. A useful method to evaluate bridge life is to consider the probability a bridge will be in service 75 years (many owners' expectations). Figure 1 is the Cumulative Density Function representing the Steel Beam bridge's probability of 73 percent (the best of the bridge types) of lasting more than 75 years.



**Life Cycle Costs of Short-Length Bridges**  
County bridge inventories usually record bridges whose most are less than 140 ft in length. Table 3 shows the average-perpetual present value costs and initial costs of bridges with a maximum length of 140 ft. Concrete spans and girder bridges are not common in this bridge length, they are not included. Steel beam bridges have the lowest life cycle costs and the lowest initial costs compared to the other types. A useful method to evaluate bridge life cycle costs is to consider the probability a bridge will cost less than a certain amount. Figure 2 is the Cumulative Density Function representing the Steel Beam bridge's probability of 68 percent (the best of the bridge types) of costing less than \$300,000.

Bridge Type	# of Bridges	PPVC	Initial Cost	Avg Length	Avg # Spans
Steel Beam	27	\$156.20	\$222.00	66	1.25
PVA Box - Reinforced	230	\$172.20	\$251.00	69	1.29
PVA Box - Spandrel	85	\$172.20	\$251.00	66	1.23
Box Girder	43	\$184.40	\$261.00	64	1.08

Table 3: Perpetual Present Value Costs of Bridges of 140 ft and Less



**Download the research report at**  
[www.ShortSpanSteelBridges.org](http://www.ShortSpanSteelBridges.org)

Rich Tavelletti  
Director, Short Span Steel Bridge Alliance  
Phone: 412-459-9272  
Email: rta@shortspan.org

Large Database of Steel & Concrete Bridges

Thank You to PennDOT professionals for their participation Support from AISI, NSBA and AGA

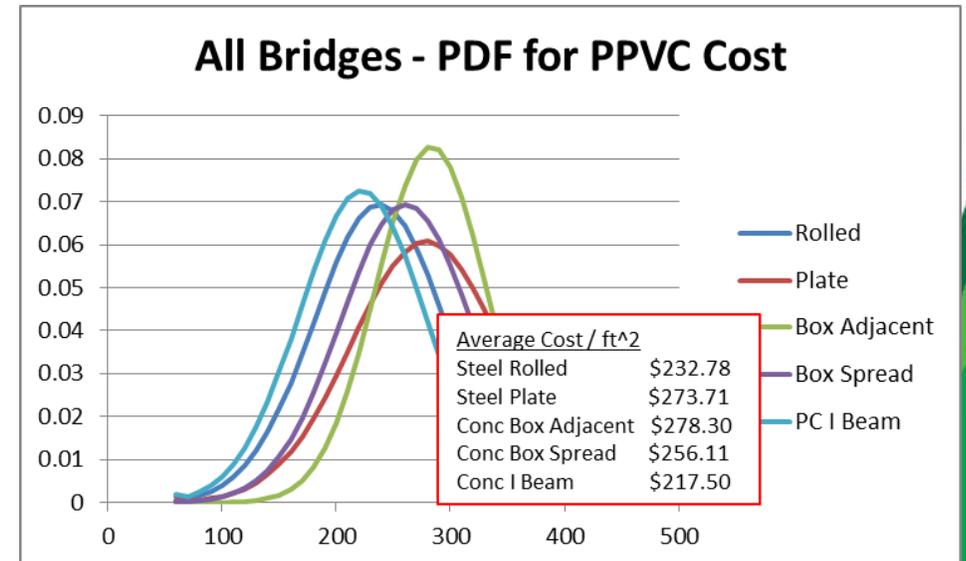
# Conclusions of Economy Studies

Typical Concrete and Steel Bridges are Competitive on Initial Cost, Future Costs, Life Cycle Costs and Bridge Life

Owners Should Consider Both Steel and Concrete Alternatives for Individual Bridge Projects

All are “similar” with  
None “Way Out” of Balance

Report on [ShortSpanSteelBridges.org](http://ShortSpanSteelBridges.org)  
Additional Report on LCC Galvanizing



# Back to Resiliency

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## Resilient Bridges

- Service Life & Life Cycle Performance
- Robustness for Unexpected Demands: Seismic, Natural, Man-Made
- Rehabilitation & Strengthening
- Inspectable & Repairable
- Sustainable

~~But, the Bridge Also Needs to Be Economical~~  
Consider Both Steel & Concrete Bridges

# Resilience - Service Life & Life Cycle Performance

## 1000's of Steel Bridges Over 100 Years Old



### Steel Bridge Longevity

- Practical and Effective Design
- Durable Materials
- Inspection, Maintenance & Repair
- Corrosion Protective Systems – Steel Chemistry and Protective Coatings

# Resilience: Robustness for Unexpected Demands

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Steel bridge robustness is a bridge's ability to withstand damage and maintain its structural integrity, especially in the face of unexpected events or local failures: **Seismic, Natural, Man-Made**

- **Ductility**

Steel can deform significantly without breaking

- **Redundancy**

Alternate load paths and ability for load redistribution

- **Lightweight Yet Strong**

Steel structures are lighter, reducing seismic forces

- **Bolted and Welded Connections**

Steel bridges use high-strength bolted or welded joints

- **Ease of Retrofitting**

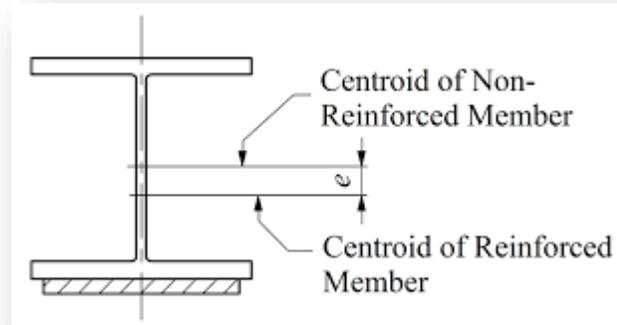
Steel bridges can be easily repaired, rehabilitated & retrofitted



# Resilience - Rehabilitation & Strengthening

## Rehabilitation & Strengthening

- Extend service life
- Restore or increase load capacity
- Prevent or mitigate corrosion and fatigue
- Upgrade for seismic or traffic demands
- Improve safety and user experience



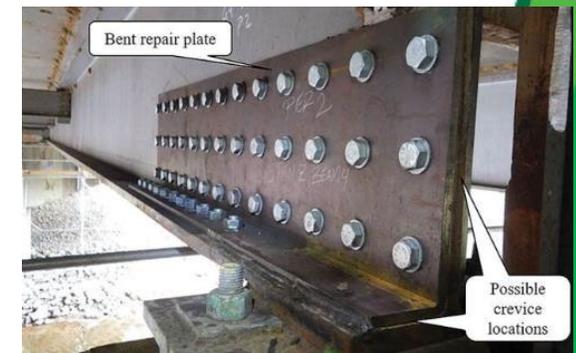
# Resilience - Inspectable & Repairable

## Structural Steel Bridge Damage or Deterioration

- Overload
  - High or wide vehicle collision
  - Fire
  - Structural vandalism
  - Fatigue
  - Corrosion
- 
- **Accessibility** - Exposed structural components
  - **Ease of Nondestructive Testing (NDT)**
    - Steel is compatible with NDT techniques
  - **Repairable Characteristics of Steel Bridges**
    - **Modular Repairs** of Damaged sections
    - **Fatigue Management** Fatigue cracks can be fixed
    - **Corrosion Repair** repainted or metalized

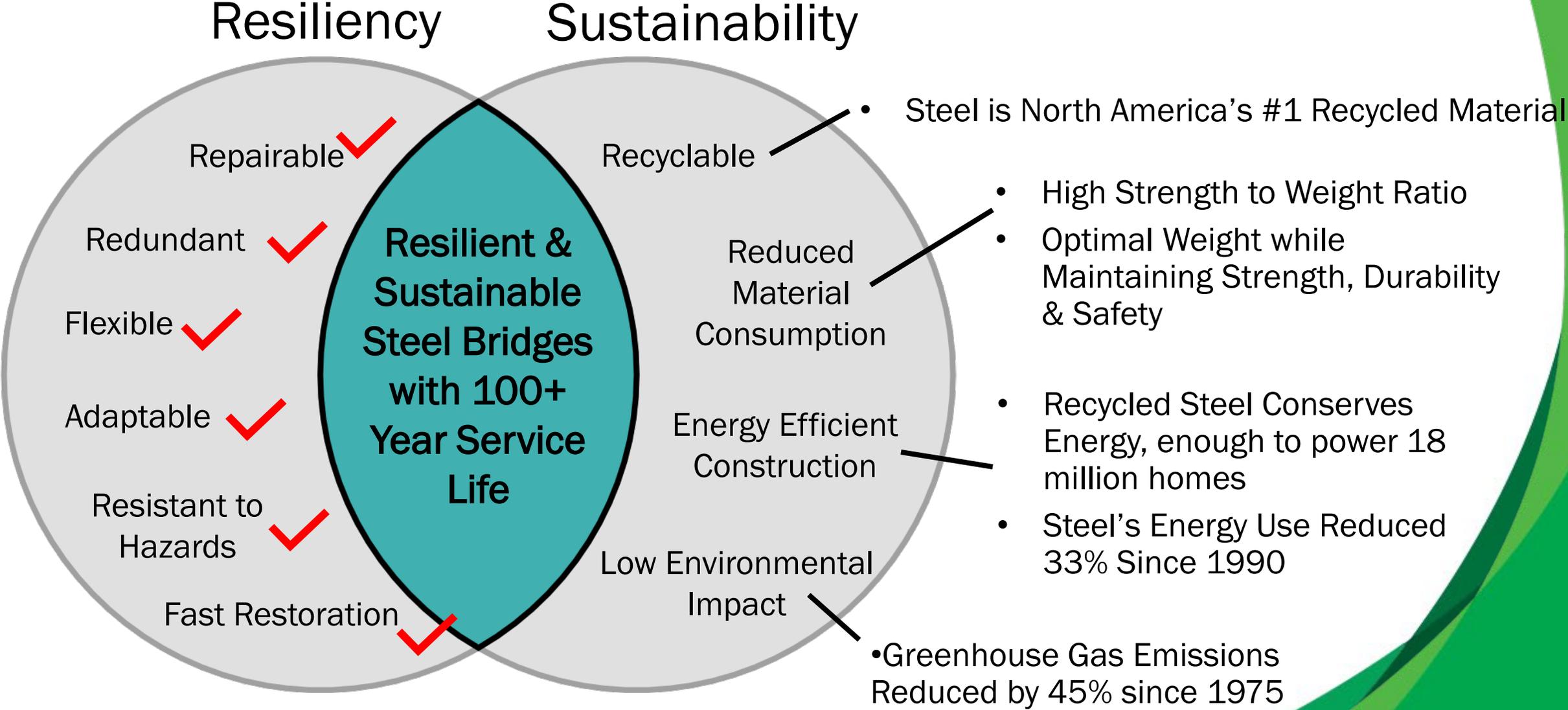


(a)



Possible crevice locations

# Crossover Between Resiliency & Sustainability



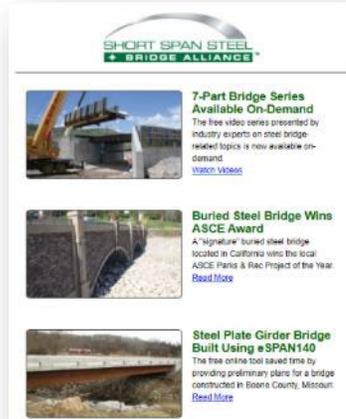
# Steel Advantages for Resiliency

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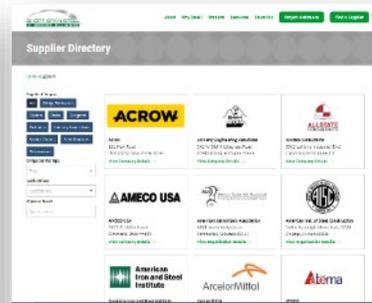
- **Strength and Durability**
  - High strength-to-weight ratios, which allows steel bridges to resist structural damage.
  - Ductile, Redundant and Robust Structure
- **Ease of Inspection/Repair**
  - Signs of problems are clearly apparent at an early stage, making steel bridges easier to inspect and repair.
- **Rehabilitation & Strengthening for Increased Loads**
  - Quickly rehabilitate & strengthen a steel bridge, while keeping the bridge in service with minimal traffic disruption.
- **Long Service Life**
  - Thousands of 100-year-old steel bridges still in service.
  - Innovative new systems have life expectancy of 100+ years.
- **Sustainability**

# 5 Ways to Keep Learning About Steel Bridges

1. Subscribe to the Weekly Newsletter



2. Find a Supplier



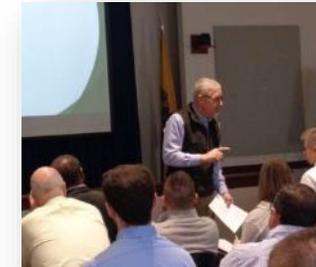
3. Design a Bridge in 5-Minutes



4. Receive Free Project Assistance



5. Schedule a Workshop/Webinar



[www.ShortSpanSteelBridges.org](http://www.ShortSpanSteelBridges.org)

Questions? Dan Snyder, Director, SSSBA, [dsnyder@steel.org](mailto:dsnyder@steel.org), (301) 367-6179



Website: [ShortSpanSteelBridges.org](http://ShortSpanSteelBridges.org)

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