Buried Bridge Solutions for Short Span Bridge Applications

Short Span Steel Bridge Workshop

New Jersey DOT
Trenton, New Jersey

February 12, 2026

Joel Hahm, P.E.
Senior Engineer
Contech Engineered Solutions
joel.hahm@contechES.com

Presentation Outline

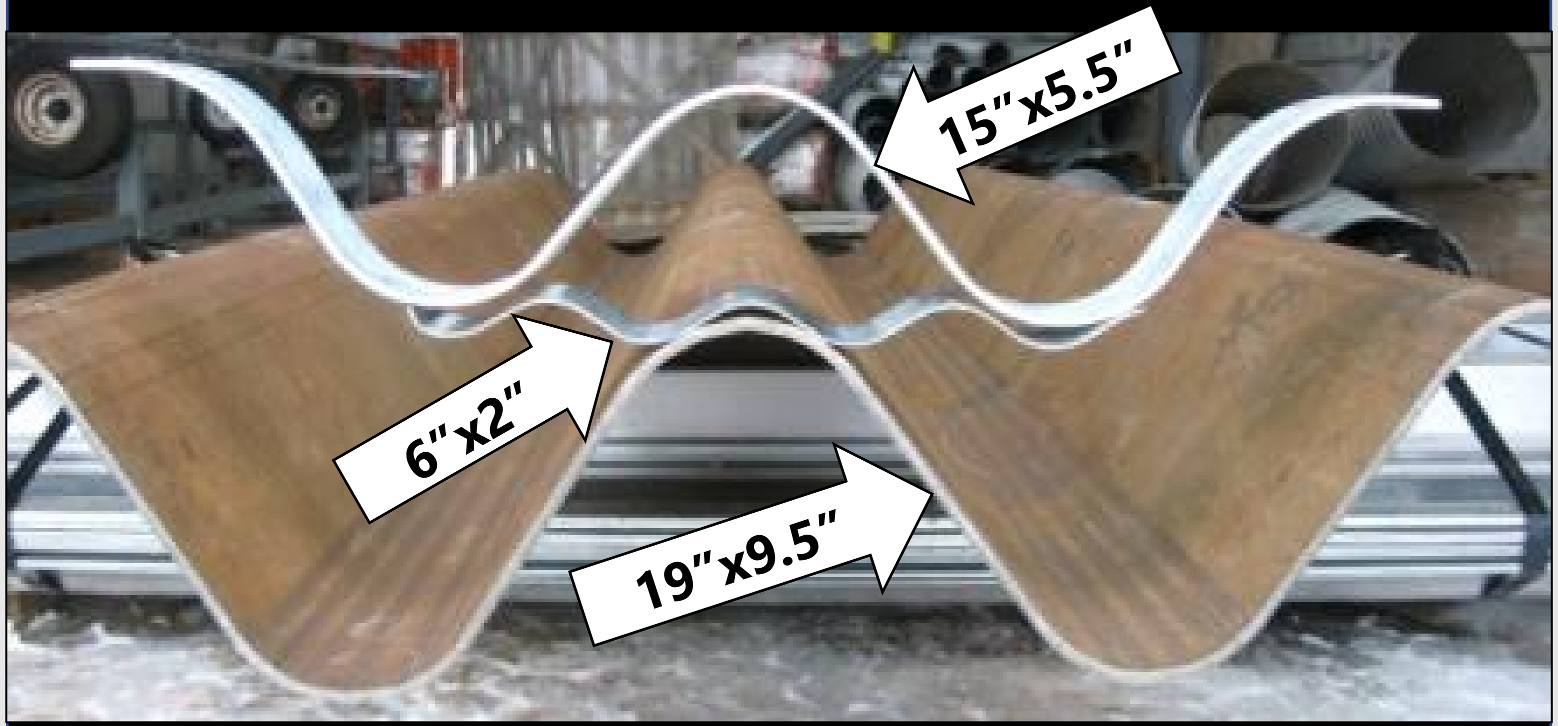
- Buried Bridges Introduction
  - Definition / materials / fabrication
  - Applications & advantages
  - Design & construction considerations
- Case Studies
  - Lawrence Road Bridge Replacement – Gray, Maine
  - Hockamin Creek Culvert Replacements – Lake County, Minnesota
  - St Johnsbury Bridge – St Johnsbury, Vermont
  - Project Snapshots

Buried Bridge Introduction

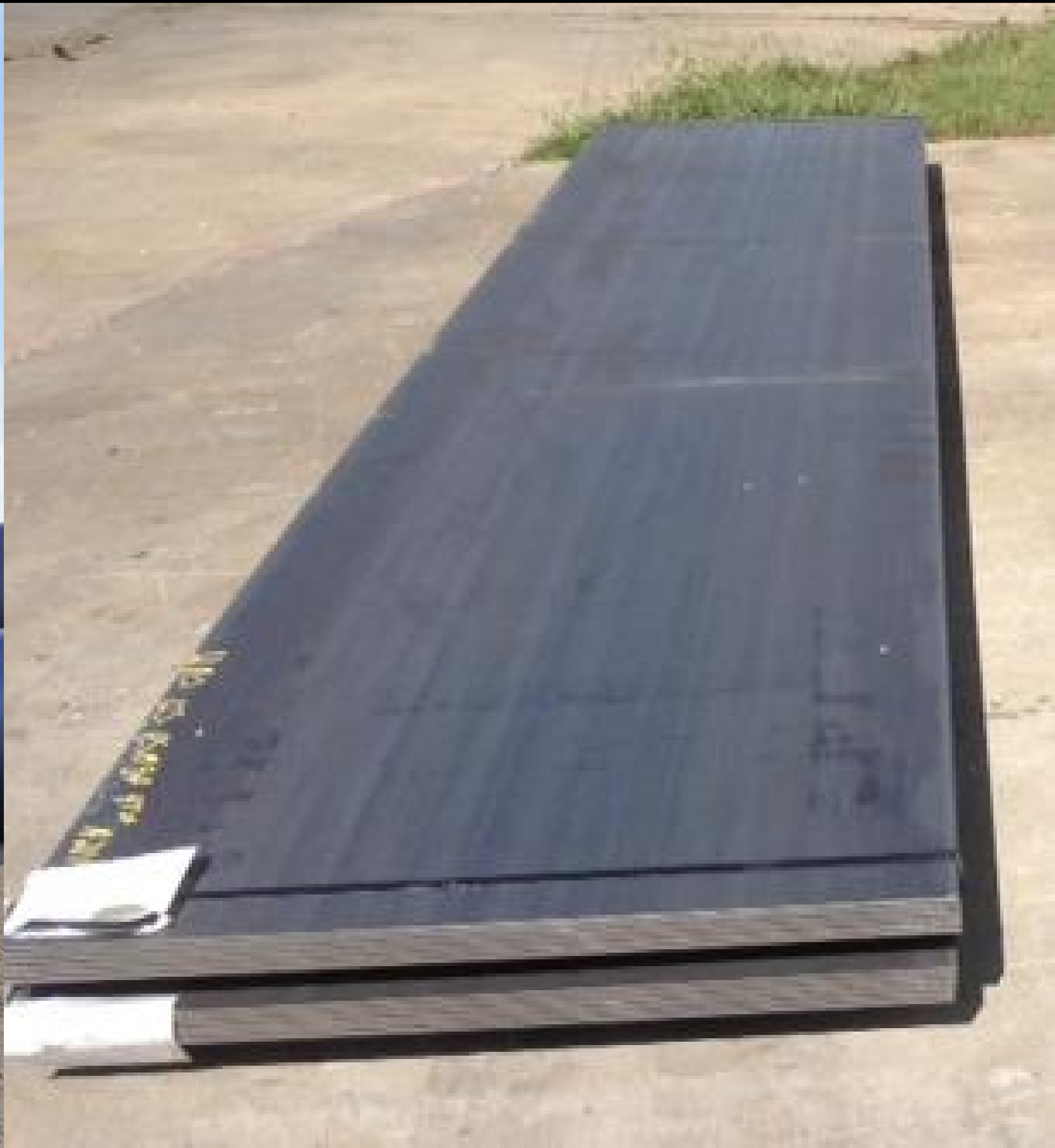
- >20’ span buried structure that works with granular backfill to support loads through soil-structure interaction
- Flexible & able to accommodate differential movement
- Subject of TRB, NACE, DOT webinars, conference sessions, & workshops – design, ABC, resilience, durability / service life, large span applications, load rating, low volume roads
- Meets all AASHTO LRFD materials, design, construction, and load rating requirements and is not proprietary. Analyzed using FEA.

Flexible Buried Bridge Materials

- Shallow Corrugated Steel Structural Plate (6” x 2” profile)
- Aluminum Structural Plate (9” x 2.5” profile)
- Deep Corrugated Steel Structural Plate (15” x 5.5” & 19” x 9.5” profiles)
- Deep Corrugated is ~9x stiffer than shallow corrugated & 6.25x stiffer than aluminum
- Deep Corrugated is ~33% stronger than shallow corrugated & ~100% stronger than aluminum.
- Differential settlement tolerance of ~6” over 50 ft.



Raw Materials – Steel Coil



Corrugating

Punching Bolt Holes

Forming – Computerized 3-Roll

Galvanizing

Shipping

Advantages & Applications

- Wildlife Crossings / AOP
- Value Engineered Solutions
- Grade Separation
- Challenging Geotechnical Conditions
- Bridge Replacement / Rehabilitation
- Structurally Redundant / Resilient
- Single Span Alternative to Multi-Cell Crossings

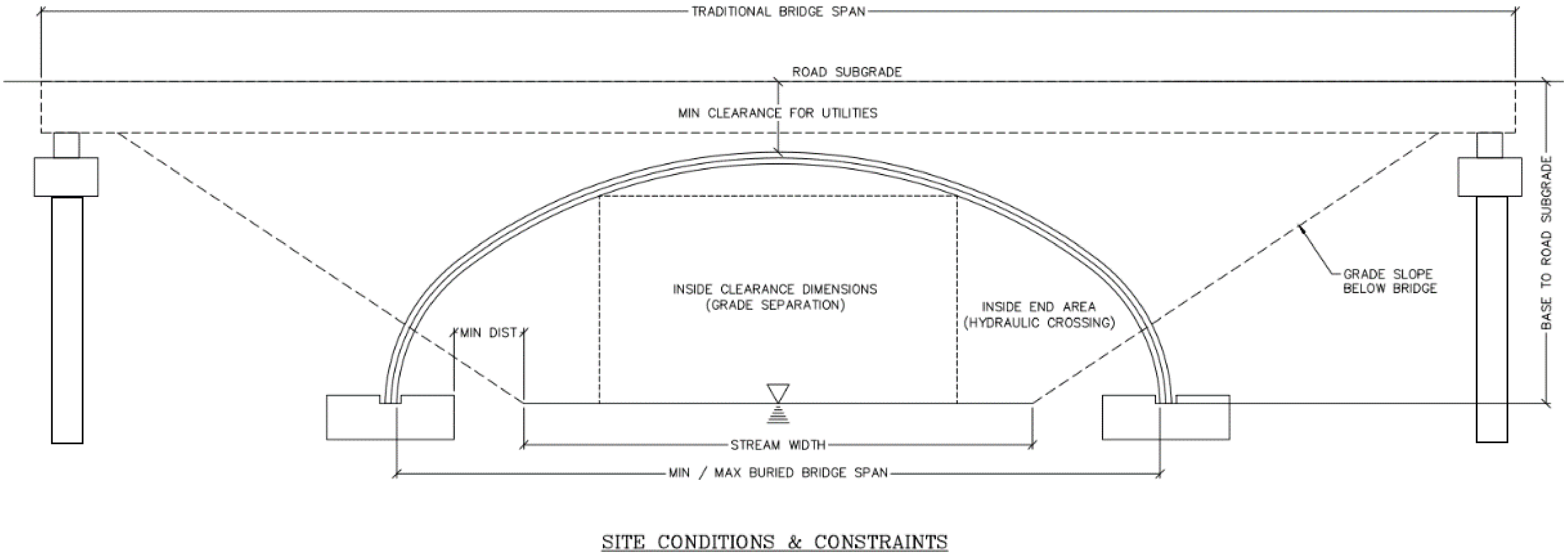
- Lower Cost Foundations
- Emergency / Temp / Detour Bridges
- No "Bump at the end of the bridge"
- Reuse Bridge Foundations
- Staged Construction
- Low Maintenance Cost & Easy to Inspect
- Able to Carry Heavy Loads

Material & Design Properties

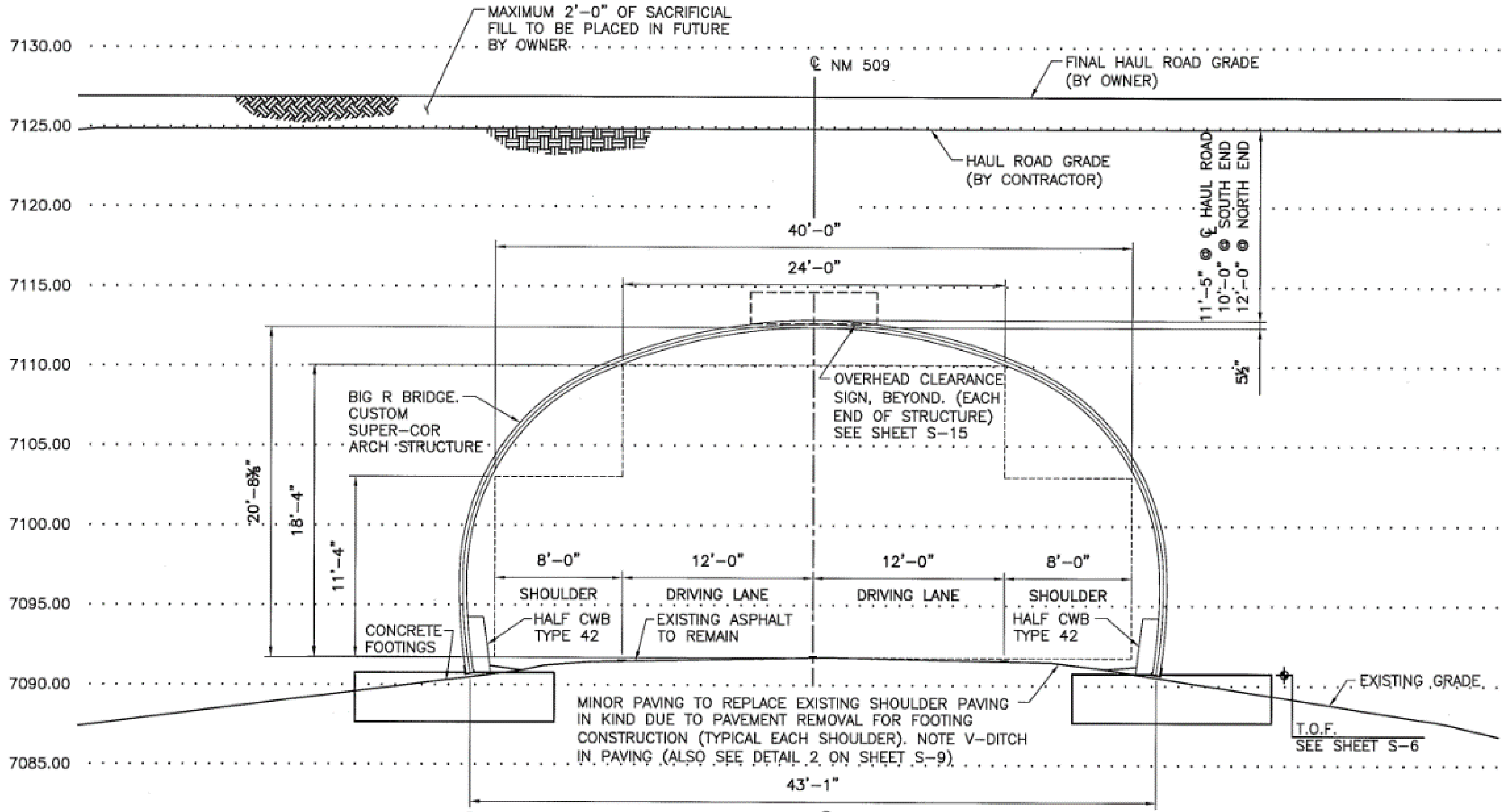
- Material properties provided in AASHTO M167 / ASTM A761
- Design properties provided in AASHTO LRFD Section 12 (Appendix A12)
- Construction specifications in AASHTO LRFD Section 26
- Thicknesses up to 0.380” thick.
- Hot dipped galvanized with 3.0 oz/ft^2 coating weight (50% more than CSP)
- ¾” or ⅞” diameter high strength steel bolts (ASTM A449)

Property	Aluminum (ALSP)	Shallow Corrugated Steel	Deep Corrugated Steel
Geometry Types	Small arch, box, closed shapes	Arches, closed shapes	Arch, box, pipe, multi-radius arches
Corrugation Profile	9” x 2.5”	6” x 2”	15” x 5.5”
Design Yield Strength	24 ksi	33 ksi	44 ksi
Relative Stiffness	~1.5 x shallow	1 (baseline)	~9 x shallow ~6.25 x ALSP

Evaluation as a Conventional Bridge Alternative



https://www.shortspansteelbridges.org/flexible-buried-bridges-part-1/



PROFILE @ ℄ HAUL ROAD
(LOOKING NORTH)


Peabody
18 FT 8 IN

Allowable Settlement

- Once the structure has been backfilled over the crown, settlement of the supporting backfill relative to the structure must be limited to control downdrag forces. If the sidefill will settle more than the structure, a detailed analysis may be required.

- Settlement along the longitudinal centerline of arch structures must be limited to maintain slope and preclude footing cracks in arches.

Calculated differential settlement across the structure taken from springline-to-springline, Δ, shall satisfy:

$$\Delta \leq \frac{0.01S^2}{R} \qquad (12.8.4.1\text{-}1)$$

where:

S = span of structure between springlines of long-span structural plate structures (ft)
R = rise of structure (ft)

More restrictive settlement limits may be required where needed to protect pavements or to limit longitudinal differential deflections.

Once the top arc of the structure has been backfilled, downdrag forces may occur if the structure backfill settles into the foundation more than the structure. This results in the structure carrying more soil load than the overburden directly above it. If undertaken prior to erecting the structure, site improvements such as surcharging, foundation compacting, etc., often adequately correct these conditions.

Where the structure will settle uniformly with the adjacent soils, long-spans with full inverts can be built on a camber to achieve a proper final grade.

For design, differential settlement between the footings taken across the structure is limited to avoid excessive eccentricity. The limit on any settlement-induced rotation of the structure maintains the top arc centerline within one percent of span, as shown in Figure C12.8.4.1-1.

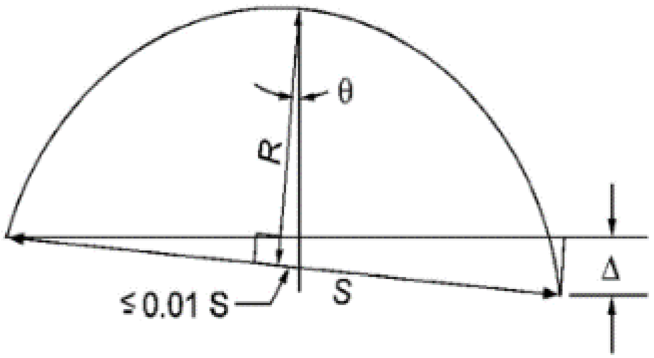


Figure C12.8.4.1-1—Differential Settlement

The rotation of the structure, θ, may be determined as:

$$\theta = \tan^{-1}\left(\frac{\Delta}{S}\right) \qquad (C12.8.4.1\text{-}1)$$

From AASHTO LRFD Section 12.8.4.1:

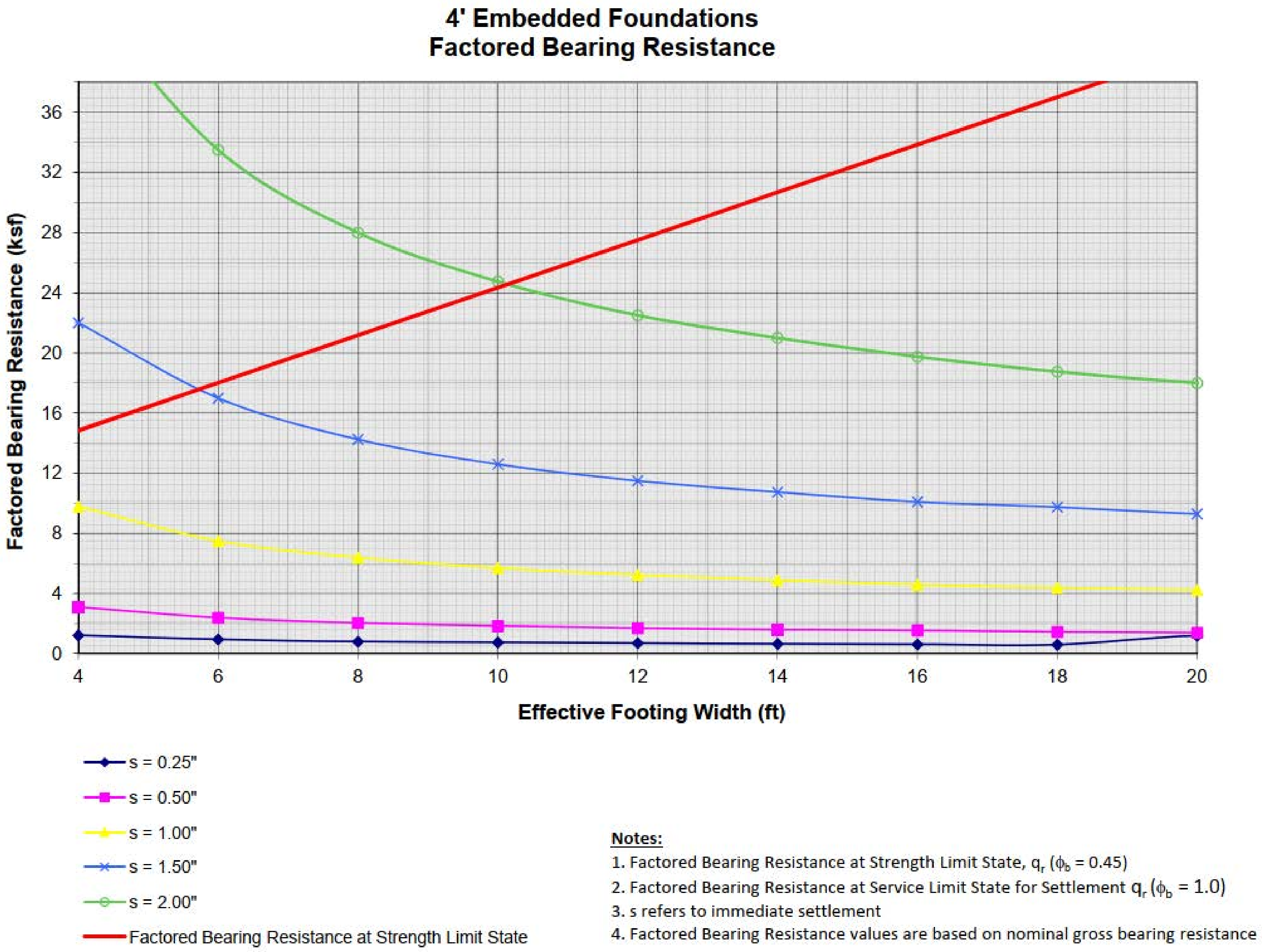
<u>Notes on Settlement:</u>

- Allowable differential settlement is a function of structure span & rise
- Structural plate structures can usually accommodate more than conventional bridges & precast structures
- Eq 12.8.4.1-1 results in higher allowable differential settlement as structure size increases – in some cases much higher than we are comfortable with.
- Rule of thumb is 6” over 50 ft across the span and 6” over 50 ft if gradual along the length for structural plate.
- Settlement tolerance of footings will sometimes govern (usually in 2-4” range)
- Considering settlement tolerance of structure will always result in smaller foundation

AASHTO LRFD Considers Settlement & Footing Width

<u>**Factors Impacting Settlement:**</u>

- Stiffness / compressibility of foundation soils (function of friction angle, soil type, cohesion, relative density, presence of water, etc.)
- Thickness of compressible layers
- Footing width
- Applied footing loads
- Original stress state (original vs final grade elevation)
- **No matter what footing design method is used (LFD or LRFD), there should be an option to increase bearing pressure by incorporating soil improvement – almost always more economical than larger foundations**

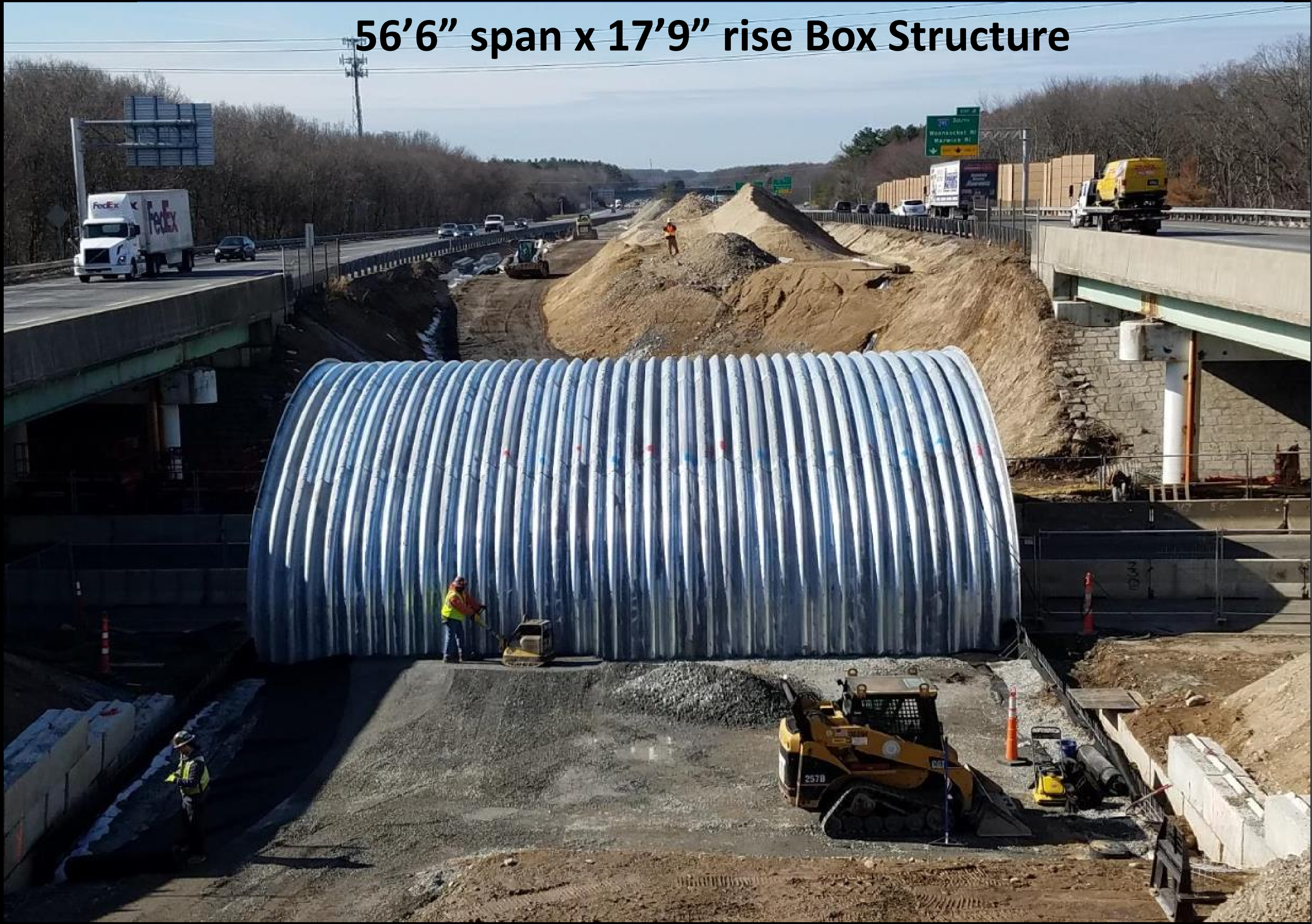


Case Studies

- I-95 Temporary Bridge – Attleboro, Massachusetts
- I-44 Bridge Replacements – Lawrence County, Missouri
- I-5 / SR509 Veterans Tunnels – Des Moines, Washington
- St Johnsbury Bridge Replacement – St Johnsbury, Vermont
- Additional Projects

I-95 Temporary Bridge over North Ave Attleboro, MA

- Carrying I-95 traffic during replacement of twin bridges
- VE alternative to Bailey Bridge
- Saved 4mo & over $1 million on project & won job for contractor
- 100 plates assembled in one 16hr day by first time contractor
- Incorporated MSE Wire Headwalls to avoid interference with new bridge abutments.




DEERE
220D
W
United Rentals


DEERE
LOAD FRAME

1 Year in Service

I-44 over Route 96 Entrance Ramp & CR 1147– Lawrence County, Missouri

Fabricator:	Big R Bridge / Contech Engineered Solutions
Contractor:	Emery Sapp & Sons
Design Engineer:	Lochmueller Group / Parsons Engineering

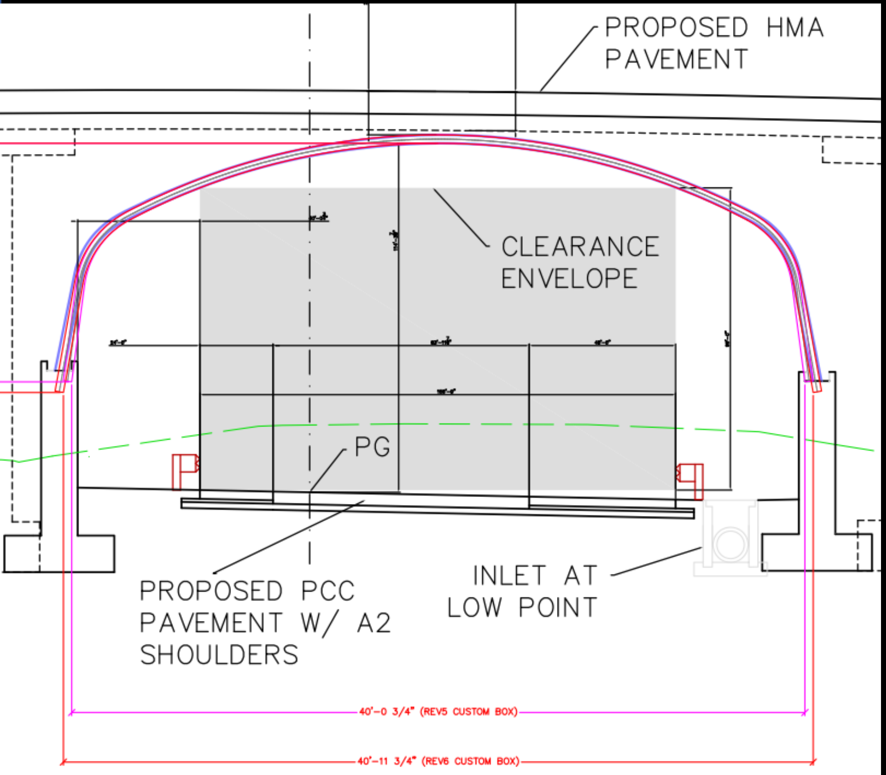
Existing Structures to be replaced – Precast & Steel Beam Bridges

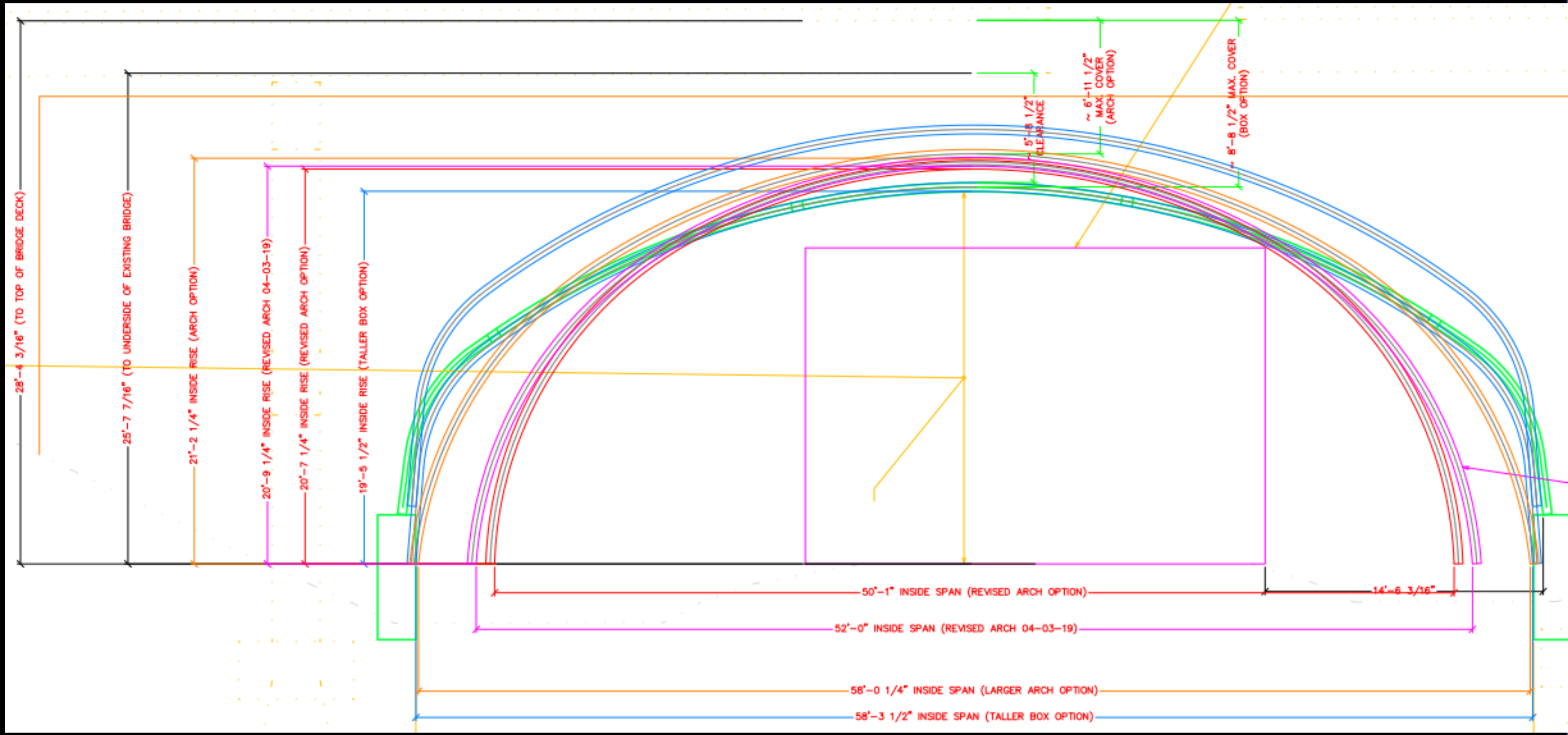

I-44 over Entrance Ramp from Route 96 to EB I44


I-44 over CR 1147

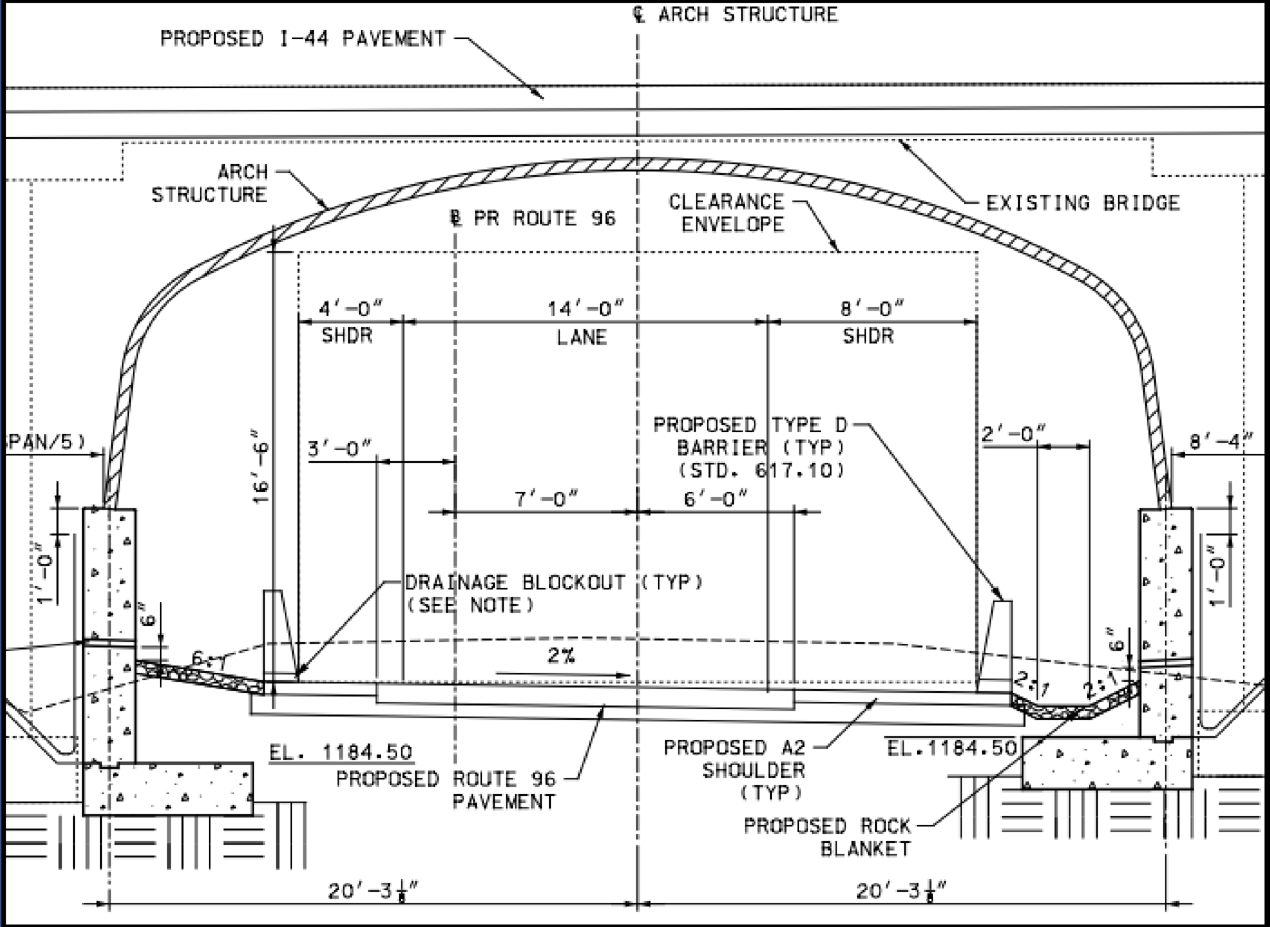
Development of Custom Structure Geometries (iterative process)

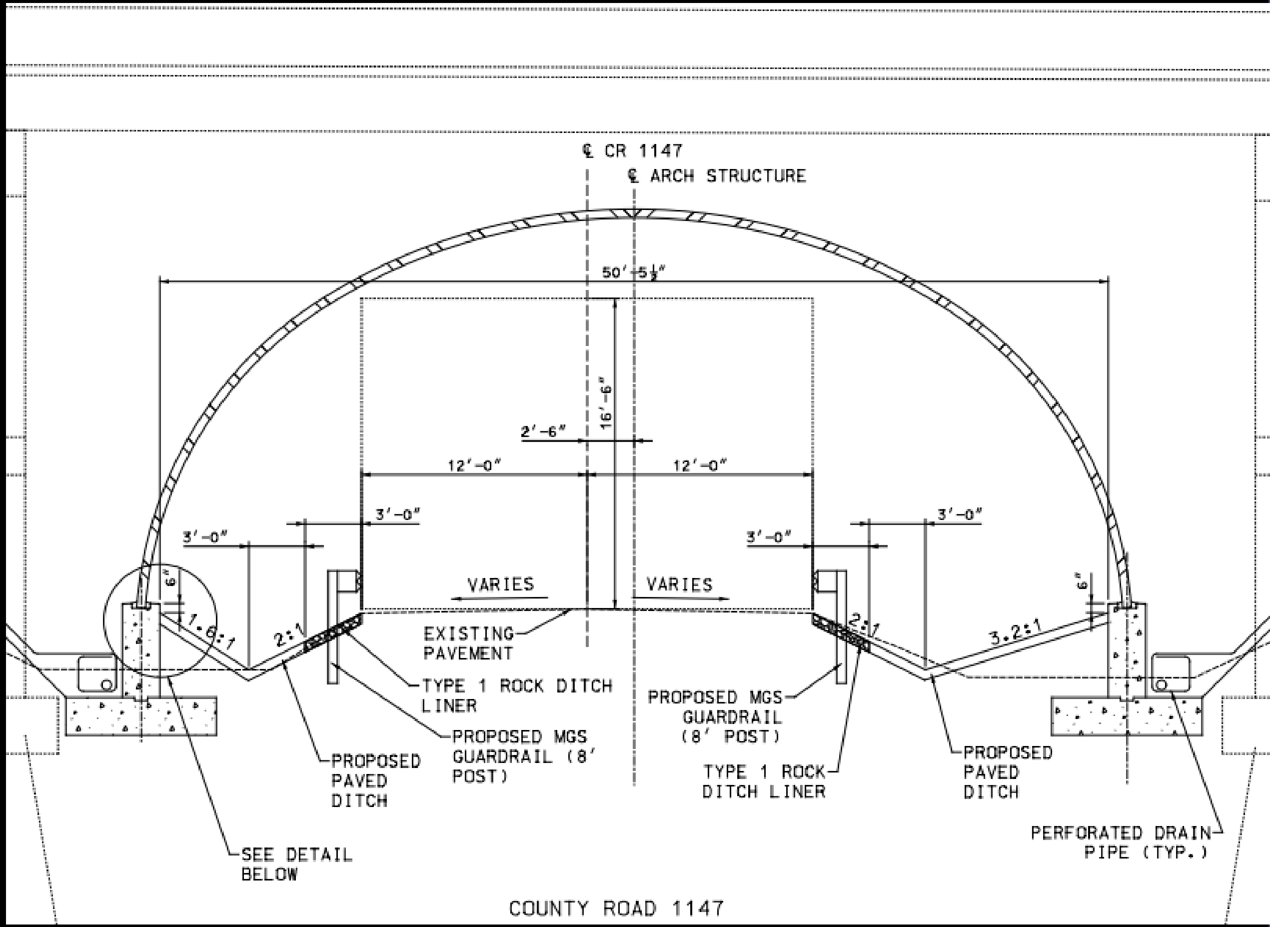
- Minimum inside clearance for vehicles
- Final top of road elevations, AASHTO cover requirements
- Avoid conflicts with existing bridge elements & site features





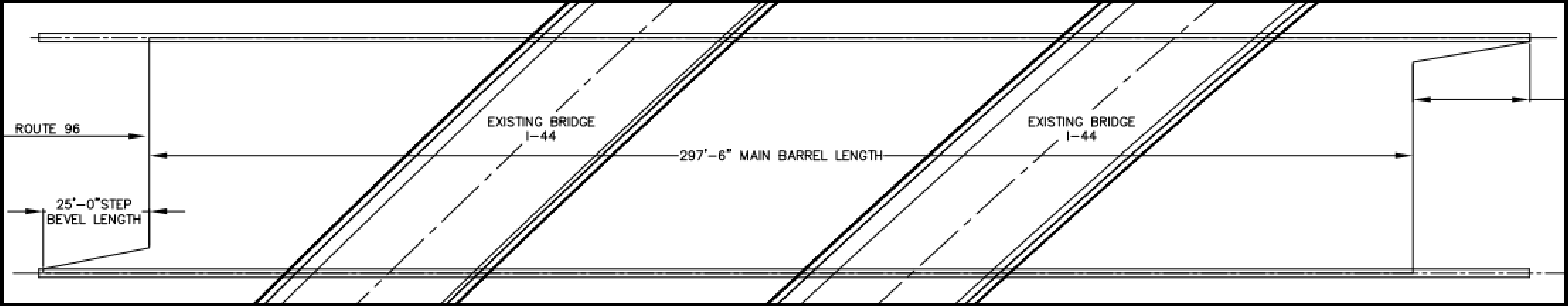
Final Geometries: Box shape for Rt 96 & Arch for CR 1147





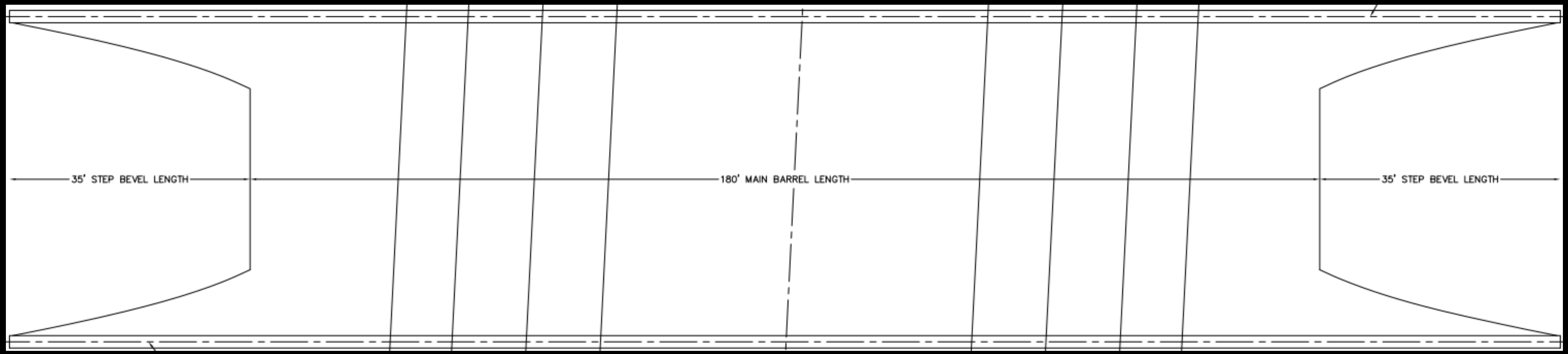
Customized layouts & end treatments to accommodate site configurations:

Rte 96 – unbalanced step bevel to address skewed alignment with I-44



Customized layouts & end treatments to accommodate site configurations:

CR1147– step beveled ends to match fill slope



Assembly & backfilling took place with existing bridges in service – Route 96






Assembly & backfilling took place with existing bridges in service – CR 1147

- **Structure Selection Factors**
  - Weight vs. span capabilities
  - Limited head room to construct below existing bridges
  - Speed of construction
  - Lower cost of maintenance (no bridge deck, bearings, barrier walls, approach slabs, abutments, joints)
  - No head to head traffic during construction
  - Simpler / faster bridge inspection
  - Mowable slopes
  - Ability to extend to add future lanes

- **Installed Cost & Time Comparisons**
  - Anticipated construction time was 8 months for precast/conventional options vs. 5 months for buried bridges
  - $3.5 million estimated installed cost for precast/conventional options vs. $3.0 million for buried bridges
  - Foundation construction time & cost savings, advantages of spread footings vs. deep foundations
  - Reduction in long term maintenance costs

Buried Bridge Innovations for Extension of Veterans Drive Through Tunnels Below I-5 Near Seattle-Tacoma Airport

Presenters:

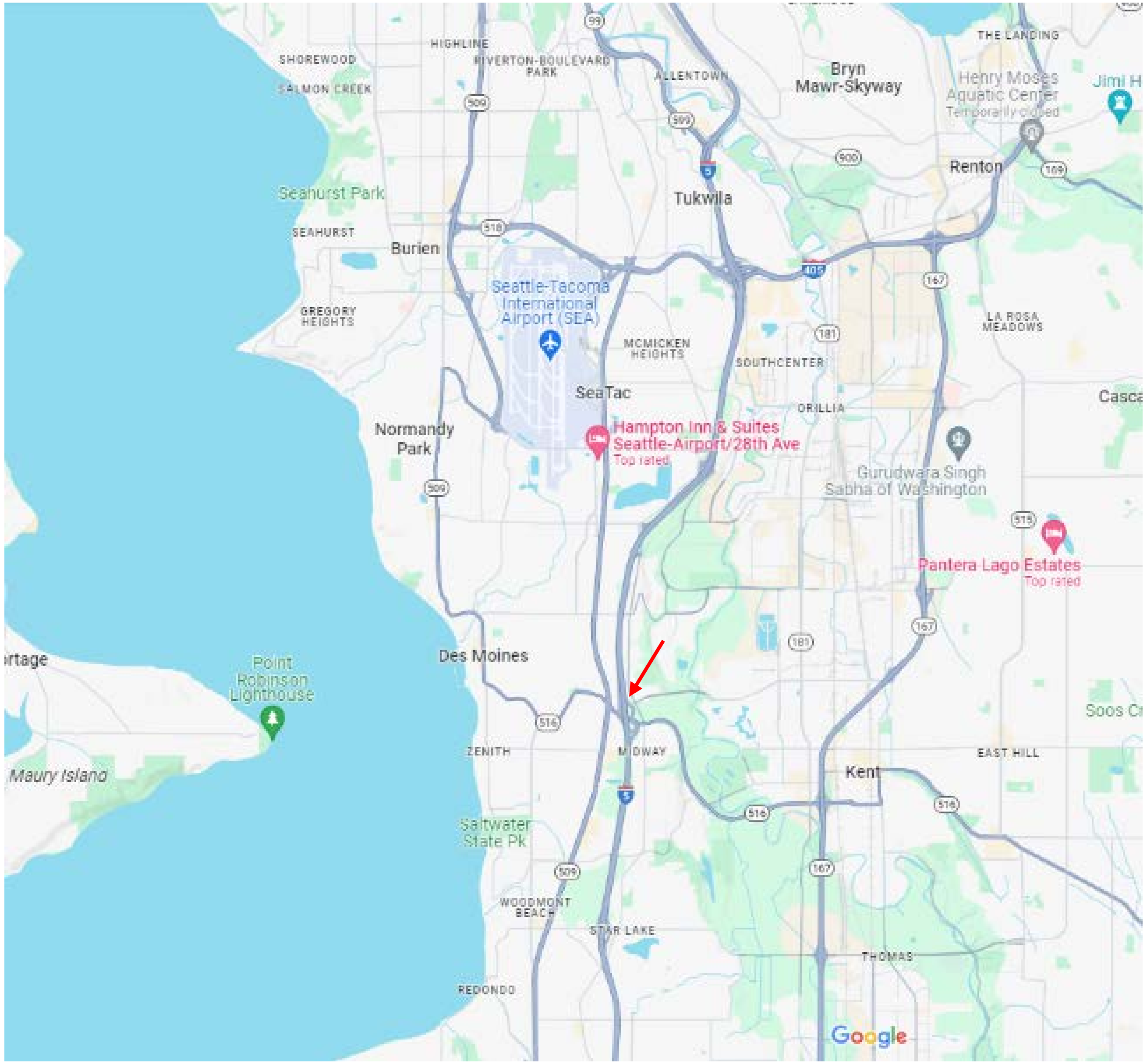
Cory Caywood, P.E., S.E.
Bridge/ Structures Design Manager
Jacobs
cory.caywood@jacobs.com

Joel Hahm, P.E.
Senior Engineer
Contech Engineered Solutions
joel.hahm@contechES.com

2025 Western Bridge Engineers' Seminar
Sept. 3, 2025
Tacoma, WA

SR 509 Veterans Tunnels – Des Moines, Washington

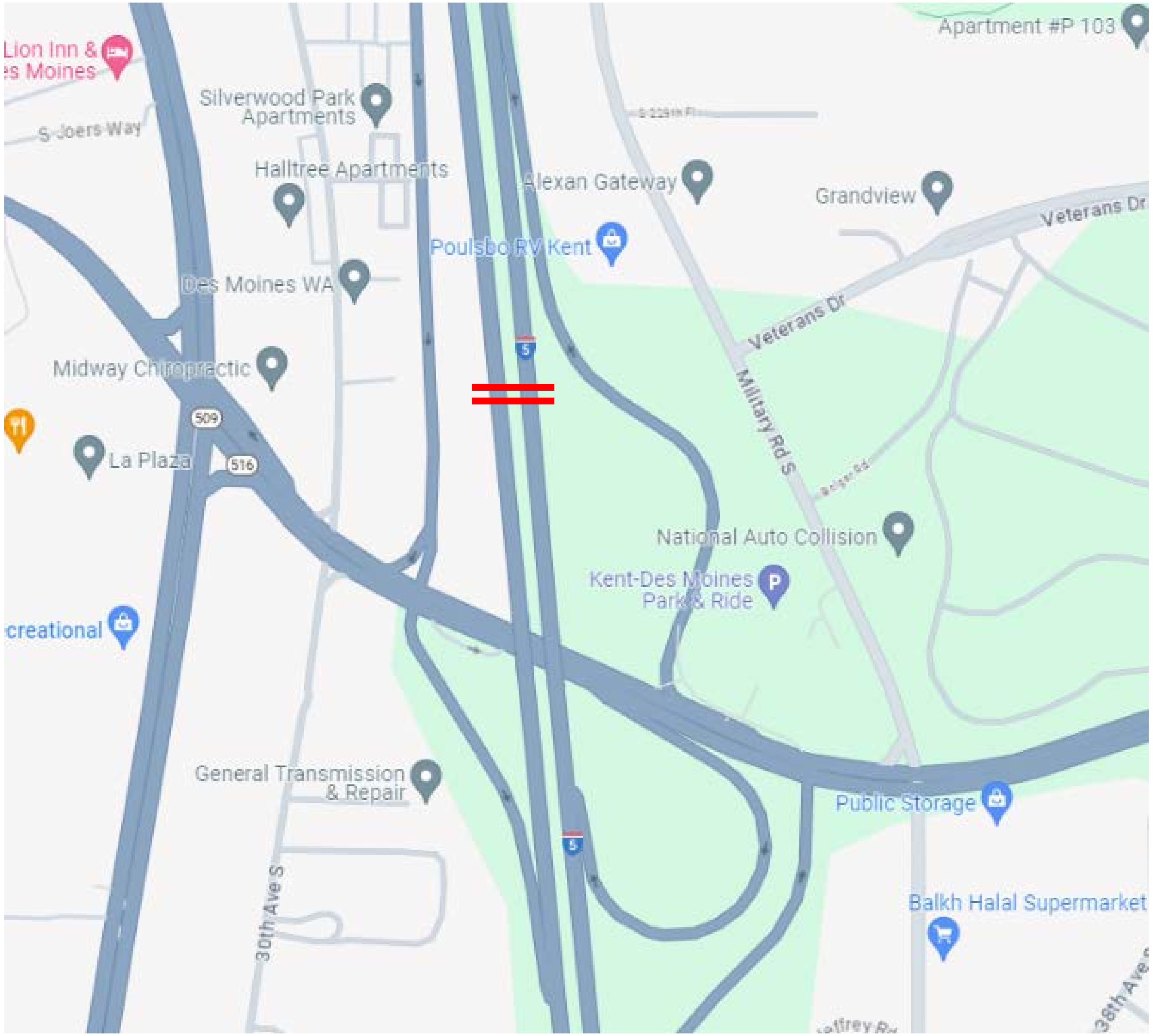
- Design-Build Project south of Seattle
- New construction of Veterans Drive below I-5 (10 lanes)
- Non-Identical Side by Side Structures (EB & WB)
- Phased Construction
- Seismic Analysis
- Structural Fire Analysis



CONTECH ENGINEERED SOLUTIONS

Project Scope

- EB & WB multi-lane roads with different inside clearance requirements (2 custom geometries)
- 10 drive lanes for I-5
- Phased construction (4 phases)
- Seismic racking analysis per WSDOT specifications
- 190 ft length required consideration of structural fire engineering analysis



SGH

STRUCTURAL FIRE ENGINEERING ANALYSIS OF CORRUGATED STEEL BURIED BRIDGES


Shokoufeh Zargar
Project Consultant


Ricardo A. Medina
Project Director


Jesse L. Beaver
Senior Principal


Joel A. Hahm
Senior Engineer

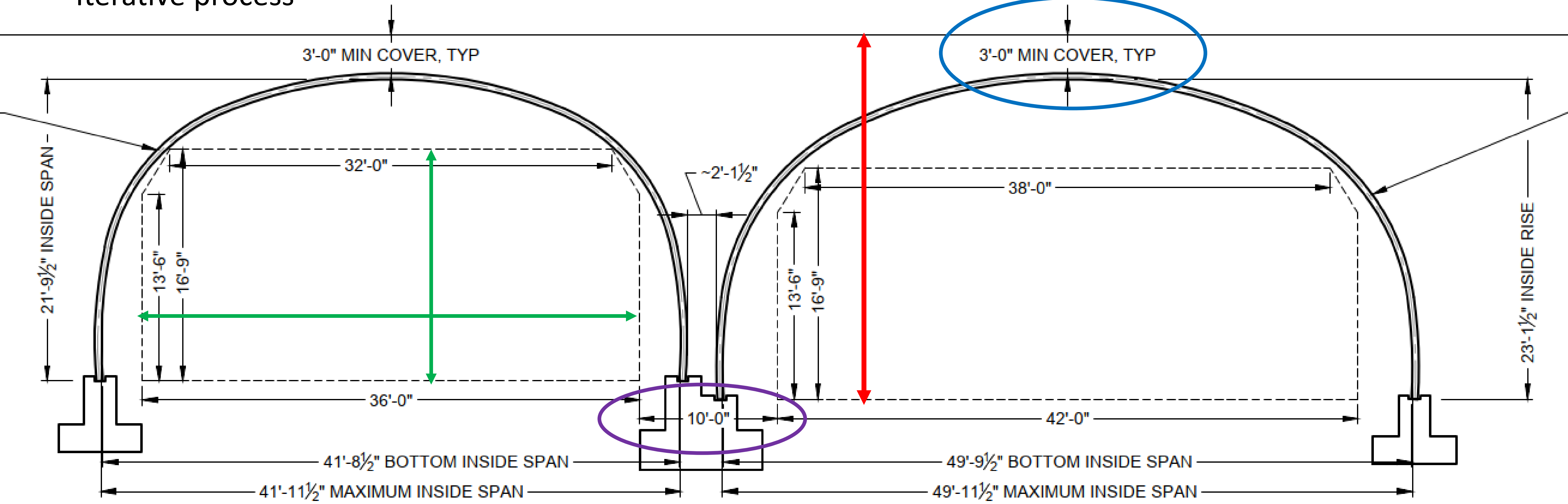
SGH

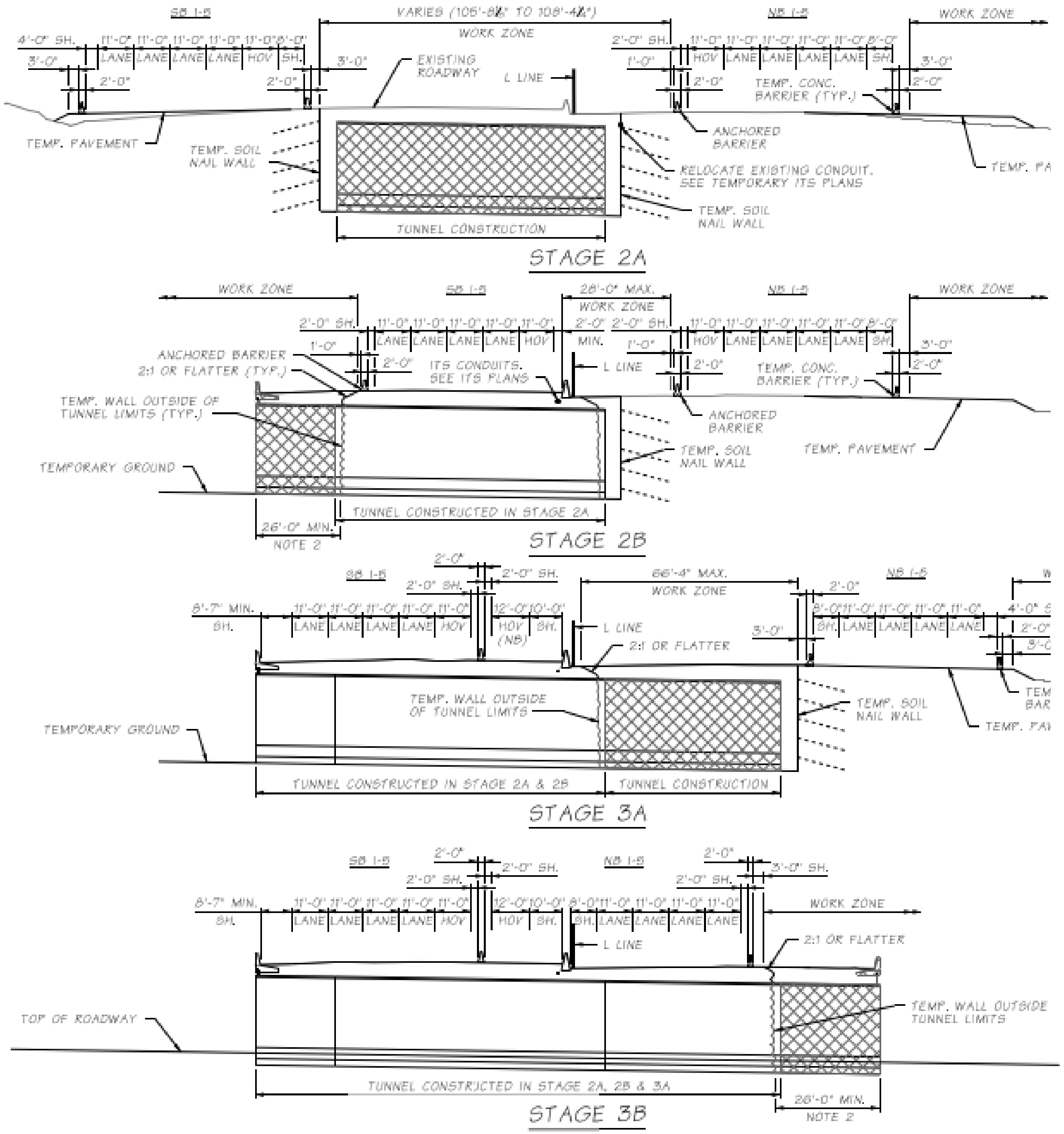
CONTECH ENGINEERED SOLUTIONS

Solution Development, Phased Construction, and Design

Solution Development

- Inside clearance / size requirements
- Road alignment
- Spacing between structures
- Vertical limitations
- AASHTO cover requirements
- Iterative process





- Construction in 4 stages, maintaining 10 traffic lanes through every stage

- Stage 2A: Excavate in center & build temporary soil nail walls, assemble first section of structure. Build temporary MSE walls at both ends of structure.

- Stage 2B: Shift SB traffic onto structure, excavate for installation of east end of structure, including permanent PCP MSE wall on west end.

- Stage 3A: Shift some NB traffic to completed section, extend structure to east, install temporary MSE wall.

- Stage 3B: Shift all traffic to completed section, finish east end of structure, build permanent PCP MSE wall on east end.


Genie GS-2669 RT


SERVICE


CAPITAL
KOMATSU
MNG
PC 290

VT Route 2B Bridge Replacement
St. Johnsbury, Vermont

47’11” span x 26’9” rise Arch

- Replacement for 139 ft 3-span steel & concrete bridge built in 1936
- Sized for AREMA clearance
- 28 day max. trail closure / 50 day road closure for all work
- 1.5 days for assembly by first time contractor, open to public in 45 days
- Incorporated MSE precast panel headwalls on curve.
- Used precast footings – sized to match anticipated settlement of approach embankments.


CAT
Genie S-40
Genie S-46
CAT

CAT
8050

Randolph, Nebraska 50’ x 17’
Grade Separation with E80 Loading


Union Township, Pennsylvania
Bridge Replacement, Skewed Ends


Craig, Alaska
Built by tribal forces

Knoxville, Tennessee
~33'+ span with step beveled ends

Skagway, Alaska 75’x25’
75’ cover with RCC


Kitzmiller, Maryland
AOP with Vegetated Headwalls


Gray, Maine
Bridge Replacement, Reused Foundation

Findlay, Ohio 48’ x 21’

I-75 Bridge Replacement, Staged Construction


Spokane, Washington
40' cover, phased construction
KOMATSU
PC 400 LC


Topeka, Kansas
Reline of 40’ span x 200’ long concrete arch under I-70

Houston, Texas
Phased Construction
Recycled Concrete Backfill
Architectural Requirements

LaCygne, Kansas 53’ x 25’
Grade Separation

Knox County, Indiana 53’ x 24’
E80 Loading

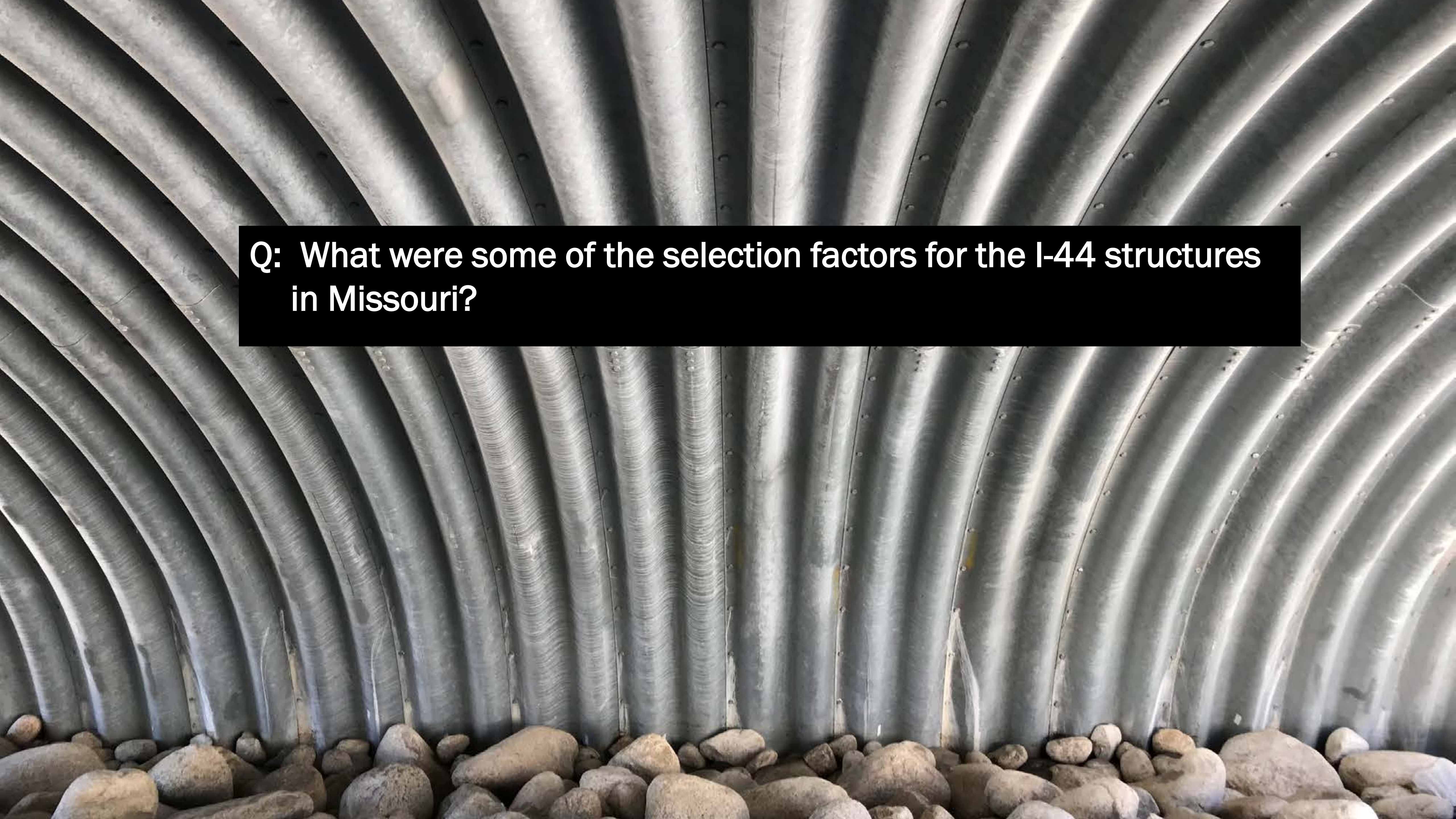

Irvine, California
Pedestrian Crossing, Sustainable Construction

Greensboro, South Carolina 53’ x 25’
Significant Settlement of Backfill


Q: True/False: Flexible buried bridge systems are proprietary.

Q: True/False: Flexible buried bridge systems are proprietary.

A: False. All of the information needed to design and manufacture steel buried bridges is contained in ASTM and AASHTO standards.



Q: What were some of the selection factors for the I-44 structures in Missouri?

Q: What were some of the selection factors for the I-44 structures in Missouri?

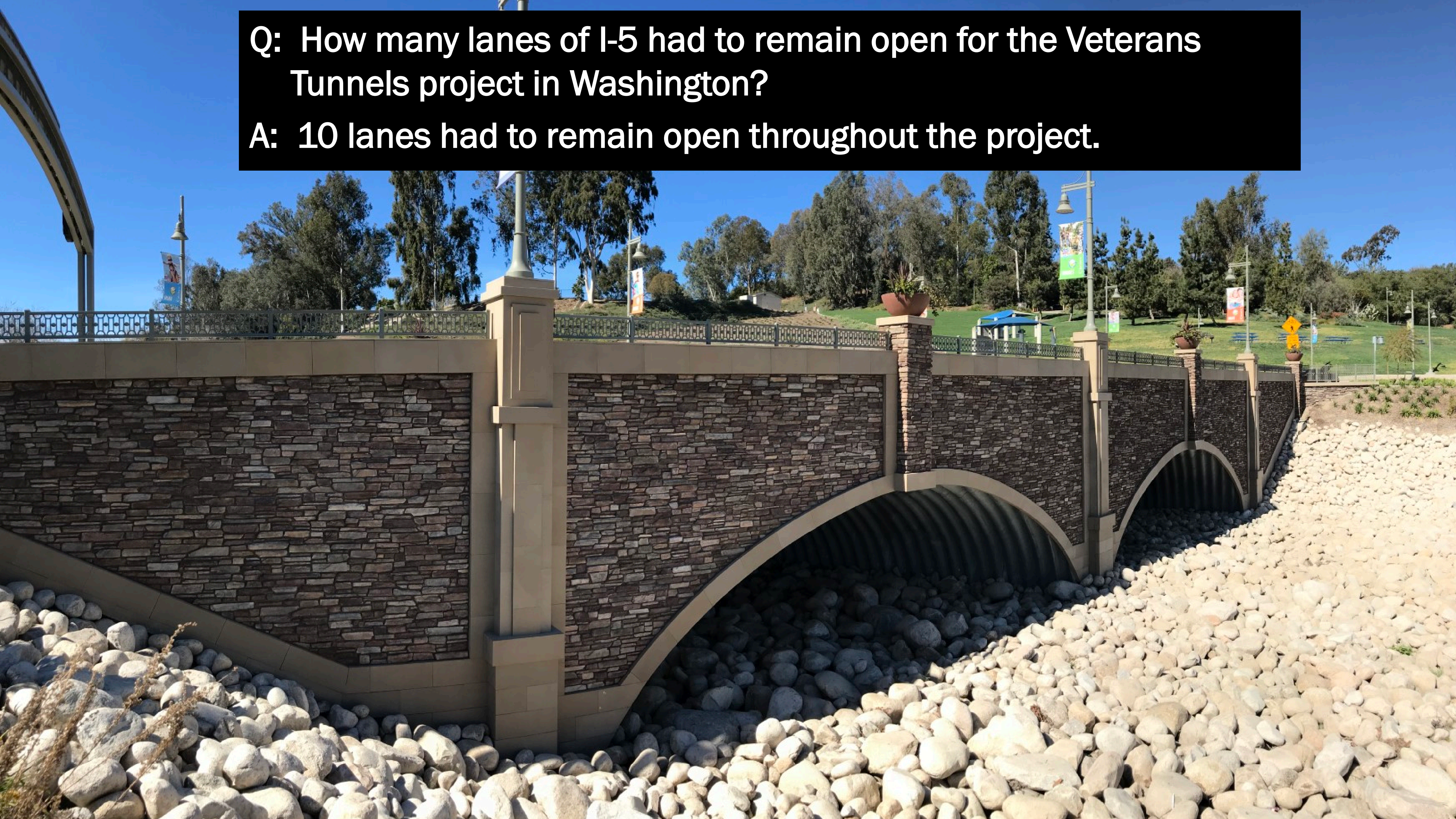
A:

- Weight vs. span capabilities
- Limited head room to construct below existing bridges
- Speed of construction
- Lower cost of maintenance (no bridge deck, bearings, barrier walls, approach slabs, abutments, joints)
- No head to head traffic during construction
- Simpler / faster bridge inspection
- Mowable slopes
- Ability to extend to add future lanes

Q: How many lanes of I-5 had to remain open for the Veterans Tunnels project in Washington?

Q: How many lanes of I-5 had to remain open for the Veterans Tunnels project in Washington?

A: 10 lanes had to remain open throughout the project.



Thank You!

Joel Hahm

Joel.hahm@conteches.com

970.590.7907

Durability & Service Life

- **Buried bridges typically have no invert**
- **50% more galvanizing than CSP and are available in much higher steel thicknesses**
- **Electrochemical requirements apply for soil & water *<u>in contact with</u>* the structure – not necessarily site soil conditions.**
- **Use same backfill electrochemical requirements as those in AASHTO LRFD Design Section 11.10.6.4.2 for MSE walls:**

    - pH = 5 to 10
    - Resistivity ≥3000 ohm-cm
    - Chlorides ≤100 ppm
    - Sulfates ≤200 ppm
    - Organic Content ≤1 percent

- **Added features/detailing like splash walls, secondary coatings, barriers, etc. can limit exposure.**
- **<u>Design considerations (site conditions, foundations, grading, proper hydraulic design, etc.) & quality of construction can have a significant impact on service life.</u>**
- ***Service life primarily depends on proper design & installation, maintenance, and what structure is exposed to. End user (owner) has greatest impact on and control over service life.***