Introduction to Buried Bridges

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Chair of TRB AFF70-1

BIG R BRIDGE®

Outline

- Introduction to Buried Bridges
- Case Studies / Applications
- Questions

Buried Bridge Overview

•Definition of Buried Bridges:

- **Buried Bridge is any bridge that derives its support from both the structure and the surrounding soil through soil-structure interaction. Structures consisting of corrugated metal are *Flexible Buried Bridges*.**
- **AASHTO LRFD Bridge Design Specifications Section 12.8.9 (design).**
- **AASHTO LRFD Bridge Construction Specifications Section 26 (construction).**
- **AASHTO Materials Specifications – M167**
- **AREMA Chapter 1, Section 4**

Knoxville, TN

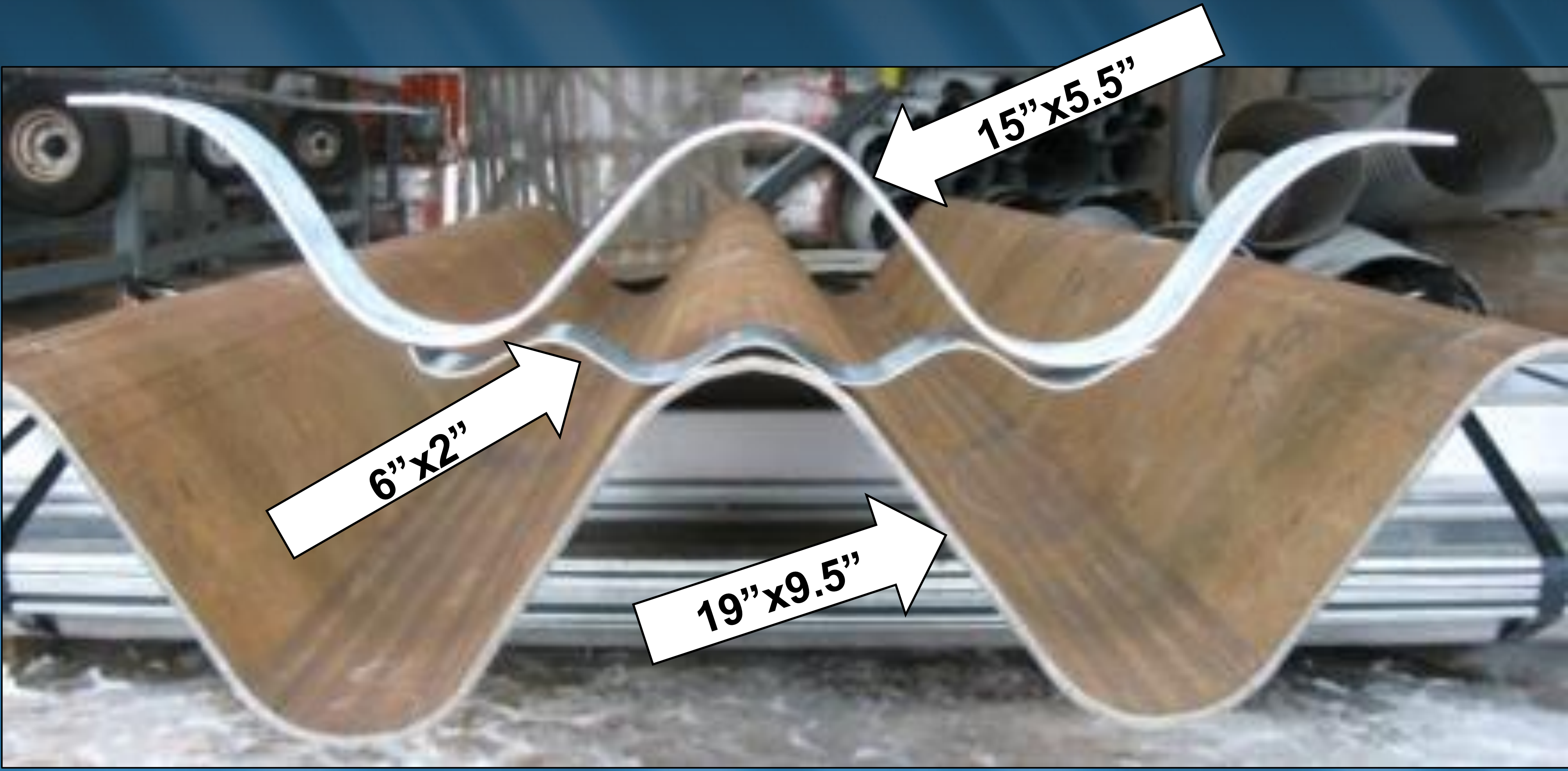
Buried Bridge Materials

• **Flexible Buried Bridge Materials and Capabilities:**

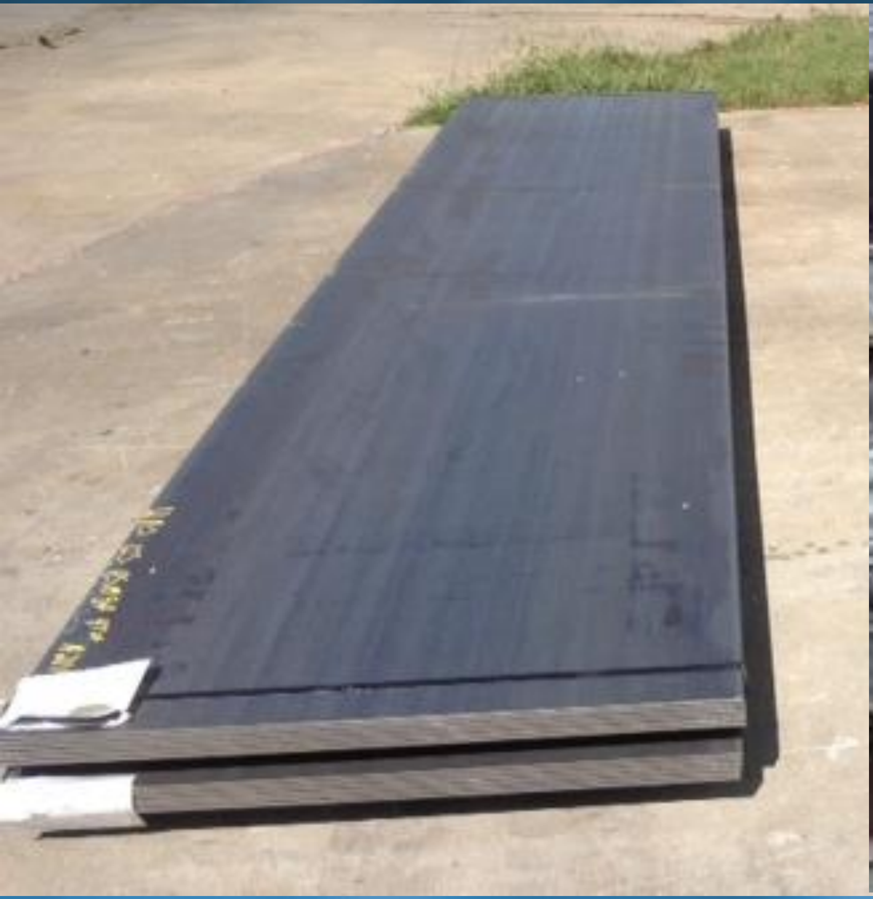
Property	Aluminum (ALSP)	Shallow Corrugated Steel	Deep Corrugated Steel
Geometry Types	Small arch, box, closed shapes	Arches, closed shapes	**Arch, box, pipe, multi-radius arches**
Span Range	10 to ~30ft	5 to ~20 ft	**10 - ~100 ft +**
Corrugation Profile	9” x 2.5”	6” x 2”	**15” x 5.5” 19” x 9.5”**
Design Yield Strength (ASTM A796)	24 ksi	33 ksi	**44 ksi**
Stiffness	~1.5 x shallow	1 (baseline)	**~9 x shallow ~6.25 x ALSP**

Buried Bridge Profiles

- Flexible Buried Bridge Materials and Capabilities:

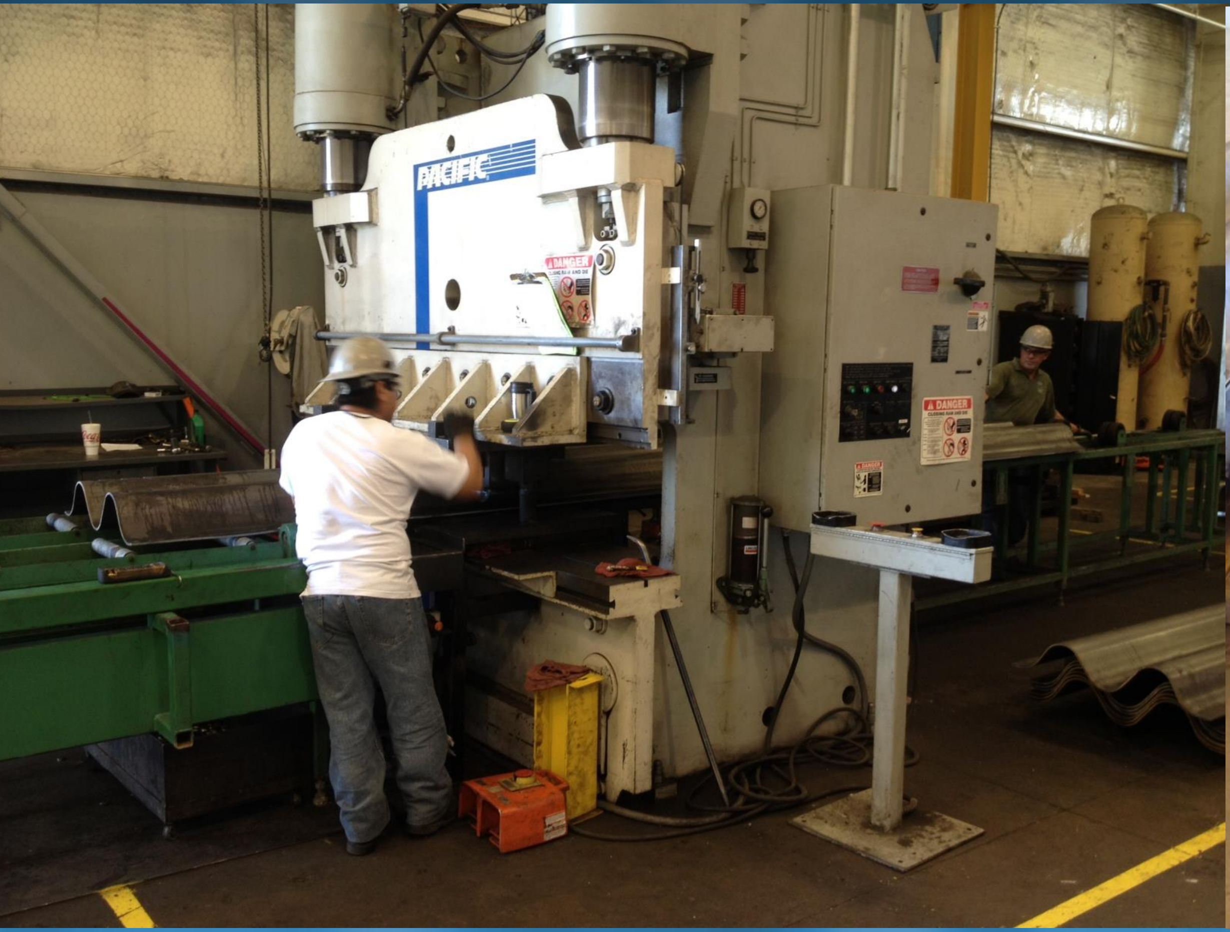


Raw Materials – Steel Coil



Corrugating

Punching Bolt Holes



Forming – Computerized 3-Roll

Galvanizing

Shipping

Buried Bridge Design

- **Shallow corrugated structures use empirical design methods – no consideration for site conditions**
- **AASHTO LRFD requires finite element analysis (FEA) for deep corrugated structures (corrugation profile depth > 5”). FHWA developed CANDE for FEA designs.**
- **Soil-structure interaction – backfill and structure work together to carry load**
- **FEA provides flexibility – possibly design heavier structure to be able to use lower quality backfill or optimize structure using high quality backfill**
- **Custom geometries provide the most economical & efficient designs**
- **Designs consider inputs based on site conditions – each design is customized to the site**

Buried Bridge Advantages

- **Advantages of Flexible Buried Bridges vs. Rigid Bridges:**
  - No bridge deck or joints or bearings to maintain, repair, or replace
  - Lower foundation costs & no bump at the end of the bridge (if foundations properly designed)
  - Able to accommodate complex site geometries & road profiles, No need to minimize bridge width (allowing for pedestrian access, bike lanes, etc.), Can be lengthened for future road widening
  - Structural redundancy, resilient, aesthetic flexibility, sustainability, enhanced safety benefits
  - Often able to reuse bridge foundations
  - ABC benefits - No heavy equipment or specialized labor skills needed for construction, Shorter design & material lead times than rigid bridges, Can be installed in days or weeks rather than months, easier & cheaper to transport.


Eddyville, OR

Edwards, MS

Durability & Service Life

- **Buried bridges typically have no invert**
- **Steel structures have 50% more galvanizing than CSP and are available in much higher steel thicknesses (currently ~1/3 inch)**
- **Backfill electrochemical requirements apply for soil & water *in contact with* 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. Considers pH, resistivity, chlorides, sulfates, organics.**
- **Added features/detailing like splash walls can limit exposure.**
- **Secondary coatings (polyurea, epoxy, asphalt, polymer, etc.) can be used in harsh conditions.**
- **Barriers can be used to shed surface water to prevent leaking and protect from de-icing chemicals**
- **American Galvanizers Association (AGA) is a good resource for information on performance of galvanized structures www.galvanizeit.org**
- ***Service life primarily depends on proper installation, maintenance, and what structure is exposed to. End user (owner) has greatest impact on service life.***

Typical Applications

•Buried Bridge Applications:

- •Bridge replacement
- •Limited site access / remote locations
- •Grade separation
- •Staged construction
- •Drainage structures
- •Rehabilitation of existing bridges
- •Wildlife / aquatic crossings
- •Environmentally sensitive crossings
- •Pedestrian access
- •Emergency / temp / detours
- •Single span alternative for multi-cell hydraulic crossings
- •Any bridge project!

Dubois, WY

Vicksburg, MS

Gray, ME

Case Studies / Applications

- Phased Construction – Spokane, WA
- Emergency Bridge Replacement – Cape Girardeau County, MO
- ABC Temporary Bridge – Attleboro, MA
- Foundation Cost Savings – Black Mountain, NC
- Bridge Replacement – St. Johnsbury, VT
- Additional Projects

US 2 Lowering – Spokane, WA

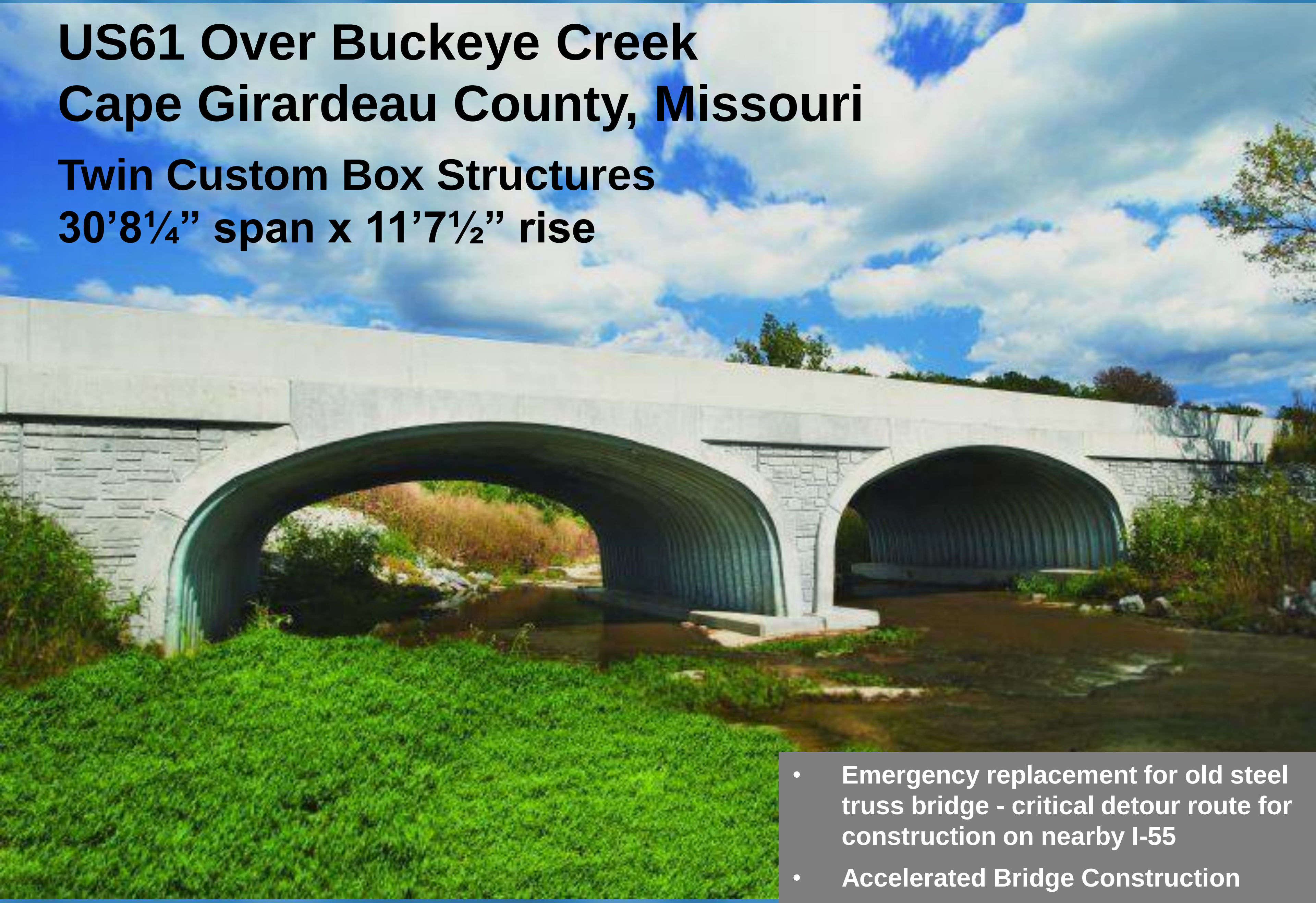
- Part of US 2 / US 395 interchange reconstruction
- Replacement of smaller precast structure to allow fish passage
- 30’ span deep corrugated steel arch with ~40’ cover
- Staged construction with temporary MSE wall & lagging wall


Stage 2
KOMATSU
PC
400
LC

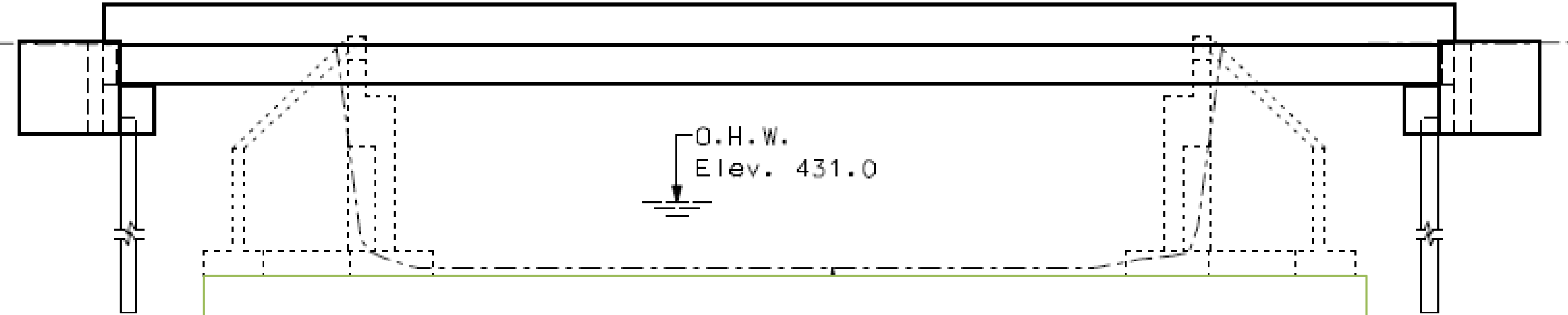
Finished

US61 Over Buckeye Creek
Cape Girardeau County, Missouri

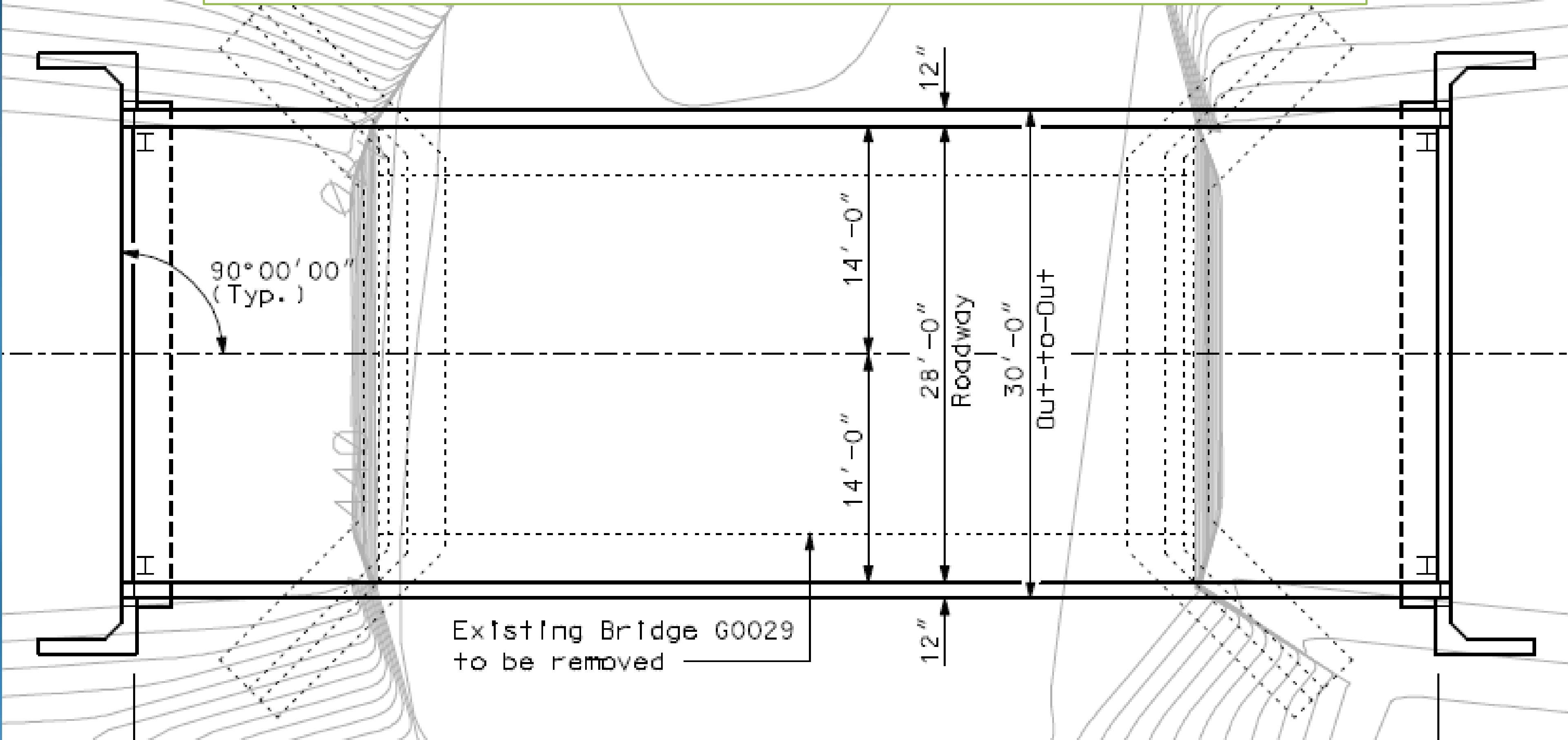
Twin Custom Box Structures
30’8¼” span x 11’7½” rise

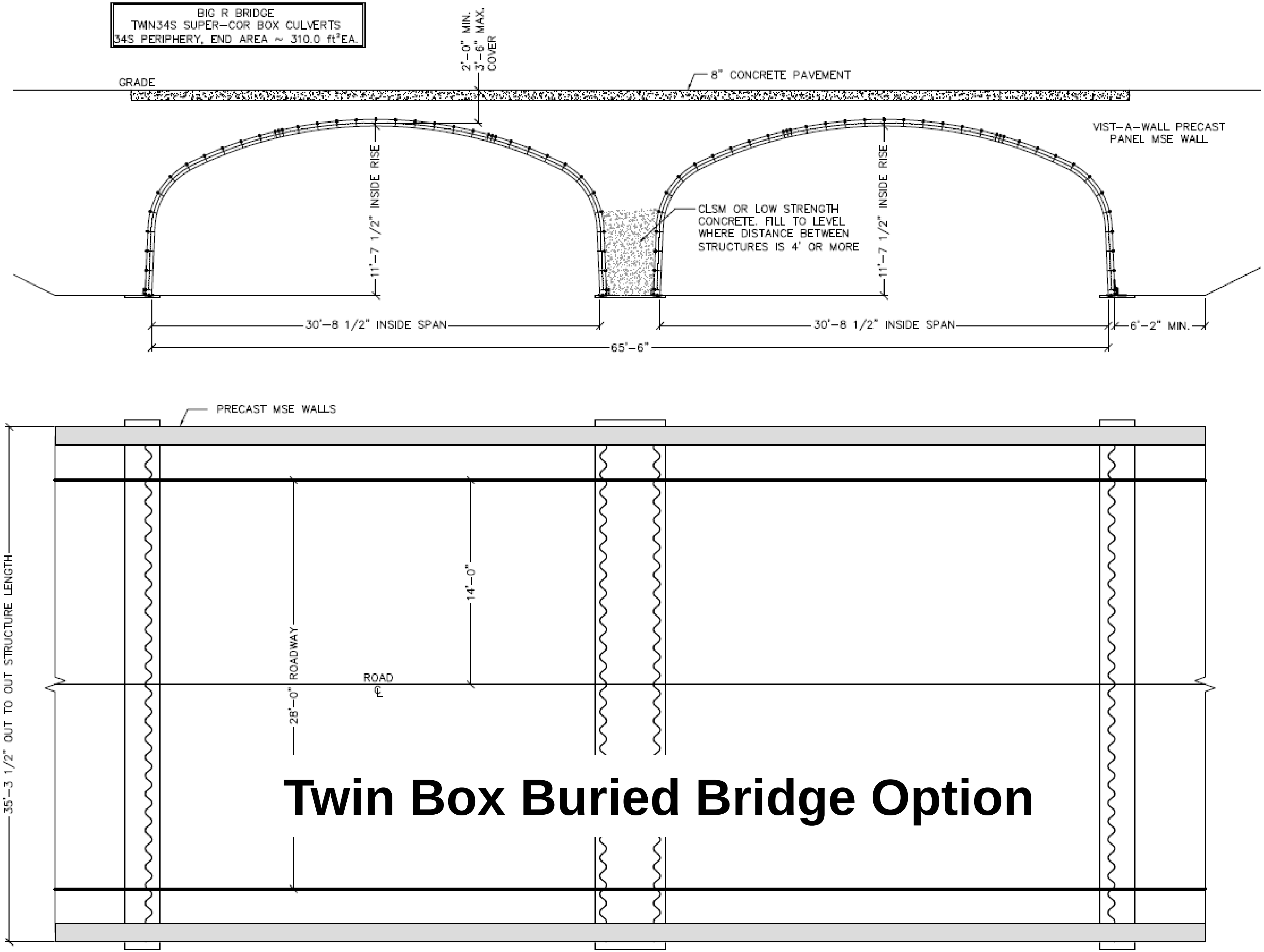


- **Emergency replacement for old steel truss bridge - critical detour route for construction on nearby I-55**
- **Accelerated Bridge Construction**
- **Incorporated MSE Headwalls.**



Original Concept: 80’ Span Precast Box Beam Bridge





Twin Box Buried Bridge Option

Structure Comparison

Conventional Precast Box Girder Bridge	Twin Span Buried Bridges
Inverted trapezoidal flow area – limited by sloped abutments	Widened hydraulic flow area at channel elevation with comparable end area
Required site re-grading	Minimal site grading – mainly finish grading
Approx. 100 ft of asphalt pavement removal & replacement beyond bridge	Less than 50 ft of asphalt pavement removal & replacement
Bridge abutments or sloped banks required	No abutments required
Required deep foundations with pile caps	Shallow foundations
45 days for design & fabrication of bridge elements only	30 days for design & fabrication of twin box culverts and precast MSE headwalls. Includes design, submittal, approval, material acquisition, fabrication, galvanizing, curing, & delivery.


7 year update

I-95 Temporary Bridge over North Ave
Attleboro, Massachusetts
56’6” span x 17’9” rise Box Structure

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

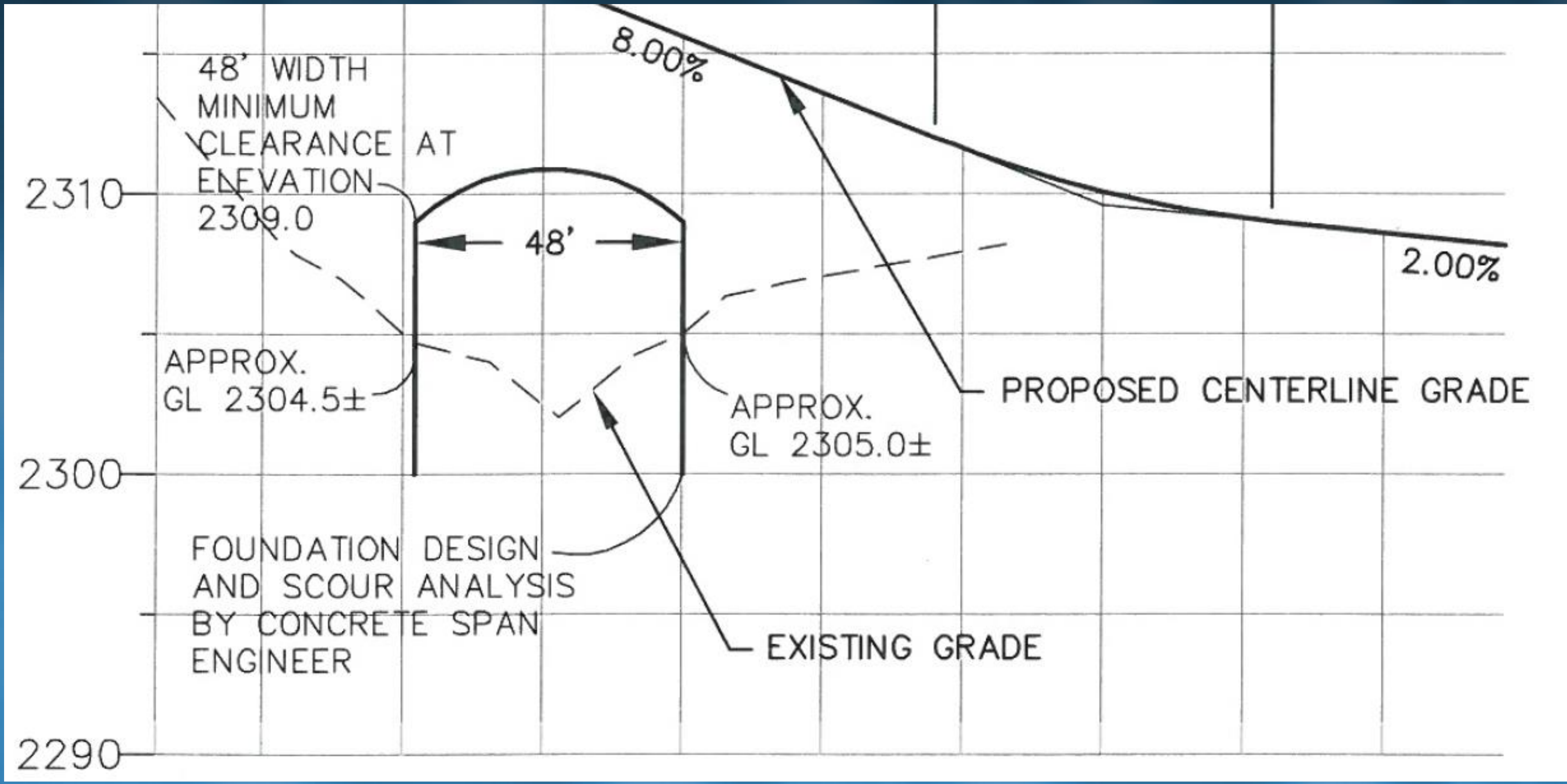

DEERE
220D
W
United Rentals


DEERE

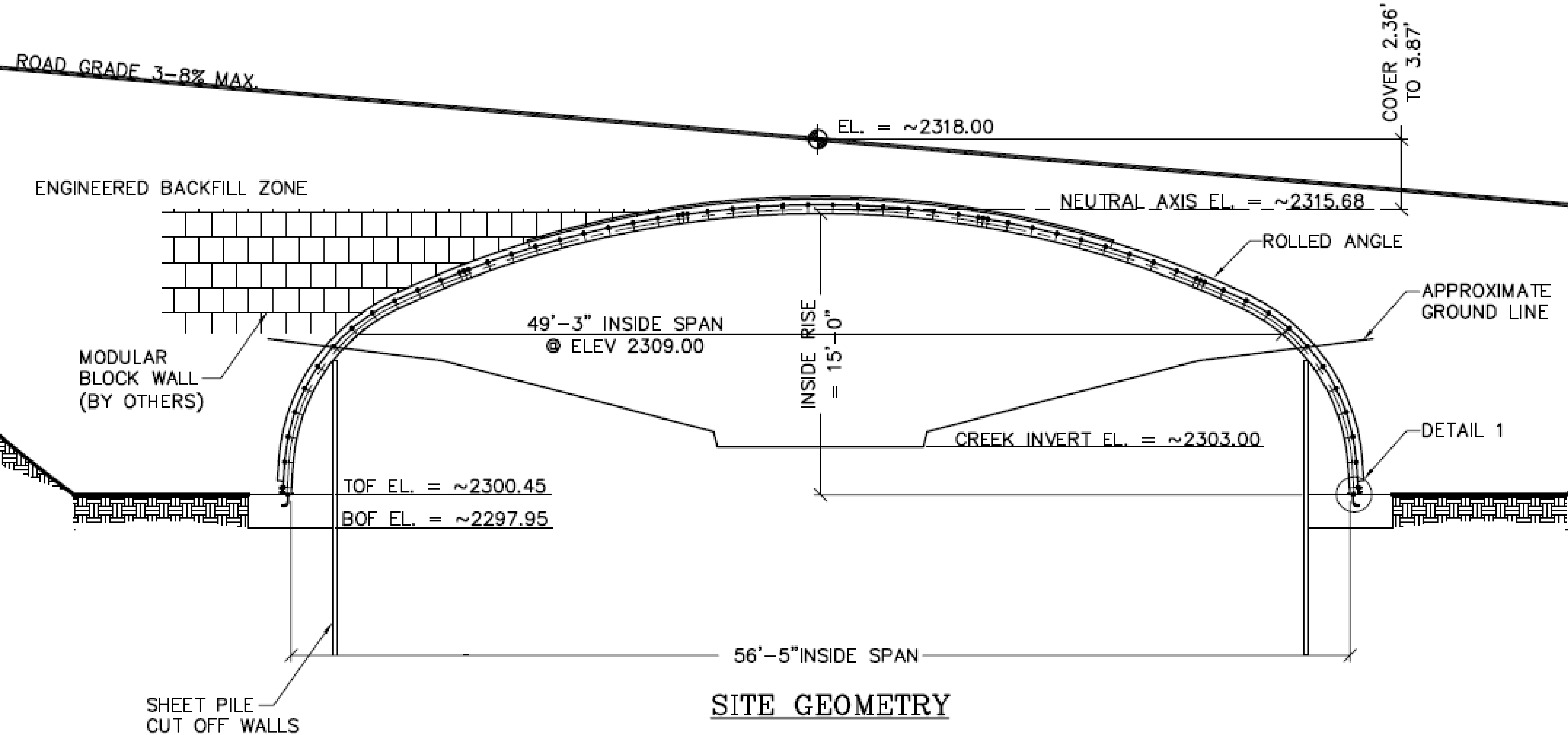
56’5” span x 15’ rise box structure
Black Mountain, North Carolina

- ~15’ distance from creek invert to road
- 48’ min clear span at 6’ above creek invert
- Stream bed soils sensitive to scour (sands)
- Wide span to get beyond limits of disturbance
- Sloping transverse grade
- Considered traditional bridge early on – would have required ~100 ft + span based on creek banks.

As Detailed in Project Documents



Buried Flexible Steel Bridge Option



SITE GEOMETRY

Cost Comparison

Item	Rigid Bridge Structure Cost	Buried Flexible Steel Bridge Structure Cost
Design, Installation, and Structure	$213,650	$205,950
Footings / Pile Caps, Ftg Excavation & Dewatering	$52,500	$101,780* * Includes cost for fnd soil improvement. Ftg larger than pipe cap.
Sheet Pile Cutoff Walls	$39,250	$39,250
H-Pile Deep Foundations	$360,000	-----------
Backfill Foundation Cut	$10,000	$15,000
Total Cost	**$675,400**	**$361,980 (-45%)**

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-40
CAT
336E


8050
CAT

http://stj2bbridge.vtransprojects.vermont.gov/index.html

Other Applications

Randolph, Nebraska
E-80 Cooper Engine, 3.67 ft cover, ~50 ft span


Gray, Maine
Bridge Replacement, Reused Foundations

Grants, New Mexico
2.7m lbs. Mining Shovel, 47 ft span

LaCygne, Kansas
RR Grade Separation, ~53.5 ft span
County Road Over Dual Track Crossing

Chisholm, Texas
Stacked Stone Headwalls


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


Laguna Niguel, California
Twin 39.7’ span x 13.2’ rise Buried Bridges
Hydraulic Improvements & Signature Entrance to City Park


Black Mountain, North Carolina
56.5’ Span VE Alternative for Precast Bridge


Houston, Texas
Phased Construction
Recycled Concrete Backfill
Architectural Requirements


Findlay, Ohio
I-75 Bridge Replacement
Phased Construction
Genie

Knox County, Indiana
E-80 Cooper Engine, 52.5 ft span


Coos Bay, Oregon
26’ span with 48’ cover

Banff, Alberta
Wildlife Crossing

Thank You!

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