I Didn't Know They Could Do That!

Capabilities and Design Considerations for Flexible Buried Bridges

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BIG R BRIDGE

Presentation Outline

- Introduction to Buried Bridges
- Design Considerations & Inputs
- Case studies / applications
- Questions

Introduction

- **Definition of Flexible Buried Bridges:**
  - **Any bridge that derives its support from both the structure and the surrounding soil through soil-structure interaction.**
  - **Generally 20 ft minimum span per AASHTO definitions or combination of smaller spans totaling at least 20 ft.**
  - **Structures consisting of corrugated metal are *Flexible Buried Bridges*.**
  - **AASHTO LRFD Bridge Design Specifications Section 12 (design).**
  - **AASHTO LRFD Bridge Construction Specifications Section 26 (construction).**
  - **AASHTO Materials Specifications – M167**
- **Flexible Buried Bridge Materials and Capabilities:**
- **Advantages of Flexible Buried Bridges vs. Traditional Bridges:**
- **Buried Bridge Applications:**

Introduction

- **Definition of Flexible Buried Bridges:**
- **Flexible Buried Bridge Materials and Capabilities:**

Property	Aluminum (ALSP)	Shallow Corrugated Steel	Deep Corrugated Steel
Geometry Types	**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 based on 0.25” thickness (3 gauge)	~1.5 x shallow	1 (baseline)	~9 x shallow ~6.25 x ALSP

Introduction

- Definition of Flexible Buried Bridges:
- Flexible Buried Bridge Types and Capabilities:
- Advantages of Flexible Buried Bridges vs. Traditional Bridges:
    - Lower foundation costs & no bump at the end of the bridge (if foundations properly designed)
    - No bridge deck or joints or bearings to maintain, repair, or replace (or keep from freezing)
    - 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.
    - Able to accommodate complex site geometries & road profiles, No need to narrow roadway (users often don't even know when they are crossing them), Can be lengthened for future road widening
    - Structural redundancy, aesthetic flexibility, sustainability benefits
- Buried Bridge Applications:

Introduction

- Definition of Flexible Buried Bridges:
- Flexible Buried Bridge Types and Capabilities:
- Advantages of Flexible Buried Bridges vs. Traditional Bridges:
- Buried Bridge Applications:
    - Bridge replacement
    - Limited site access, remote site
    - Grade separation
    - Drainage structures
    - Spans exceeding 80 ft
    - Wildlife / aquatic crossings
    - Environmentally sensitive crossings
    - Canal / utility crossings
    - Pedestrian access
    - Emergency / temp / detours
    - LVR, heavy loads
    - Phased construction

Design Considerations & Inputs

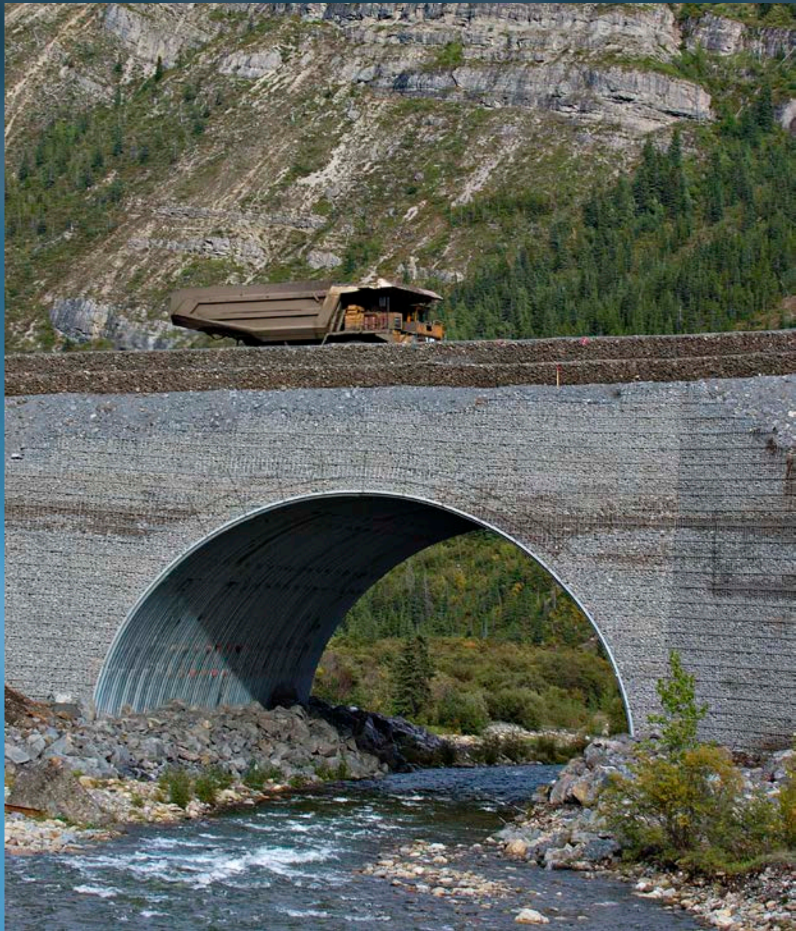
- Site Geometry Inputs:
    - Min/max clear span at xx elevation or xx ft below road
    - Inside clearance / end area
    - Hydraulic considerations – maximize span to reduce / eliminate multi-cell crossings
    - Alignment relative to road
    - Available distance from bottom of structure to top of road
    - Flexibility (raise road grade, lower foundations, encroach on clearance box, etc.)
- Geometry Type:
- Site Soil Conditions & Backfill Properties:
- Loading / Performance Requirements:
- Other Considerations:

Design Considerations & Inputs

- **Site Geometry Inputs:**
- **Geometry Type (arch vs. box):**
  - Defined by AASHTO based on ratio of crown radius to haunch/side radius: >5:1 is a box
  - 2 ft min cover for box (1.5 ft for spans ≤ 25 ft 4 in), 3 ft min cover for arch
  - Box designs governed by flexural capacity, arches by thrust capacity
  - Arch geometries are lighter / more efficient / lower structure cost
  - Not an issue for specifier or owner to be concerned with – a qualified manufacturer can determine most efficient geometry based on project requirements & site limitations
- **Site Soil Conditions & Backfill Properties:**
- **Loading / Performance Requirements:**
- **Other Considerations:**

Design Considerations & Inputs

- Site Geometry Inputs:
- Geometry Type (arch vs. box):
- Site Soil Conditions & Backfill Properties:
    - Boring logs & historical site data
    - Local geology & experience
    - Classification tests of representative materials
    - Scour depth & other hydraulic concerns
    - Identify backfill source prior to design & bidding
    - Consider site grading impacts
- Loading / Performance Requirements:
- Other Considerations:



Design Considerations & Inputs

- Site Geometry Inputs:
- Geometry Type (arch vs. box):
- Site Soil Conditions & Backfill Properties:
- Loading / Performance Requirements:
  - HL-93 is AASHTO LRFD standard – simplifies NBI load rating reporting requirements
  - U-80, mining vehicles, E-80 Cooper, heavy trucks (heavier than legal loads)
  - Special design loads require axle loads & spacing, tire size, vehicle specs (if available)
  - Design capacity is driven by axle loading rather than GVW – less impact on design than a traditional or rigid bridge. As a result, buried bridges can generally carry higher loads.
  - Consider design benefits to raising road / lowering foundations to increase cover & carry more load
- Other Considerations:

Design Considerations & Inputs

- Site Geometry Inputs:
- Geometry Type (arch vs. box):
- Site Soil Conditions & Backfill Properties:
- Loading / Performance Requirements:
- Other Considerations:

  - Custom geometries provide lowest cost solution – define project requirements & let designer find best geometry options. FEA designs can be customized and optimized to site.
  - Foundation types – design foundations based on settlement tolerance, consider foundation soil improvement to save on costs & improve quality. Biggest project cost / time savings vs. traditional & rigid bridges can come from foundations.
  - Look at project costs rather than only comparative structure costs. Construction time & labor, foundations, grading, site access, equipment, maintenance, inspection, and other costs can be very different between flexible buried bridge & rigid / traditional bridge options.

Case Studies / Applications

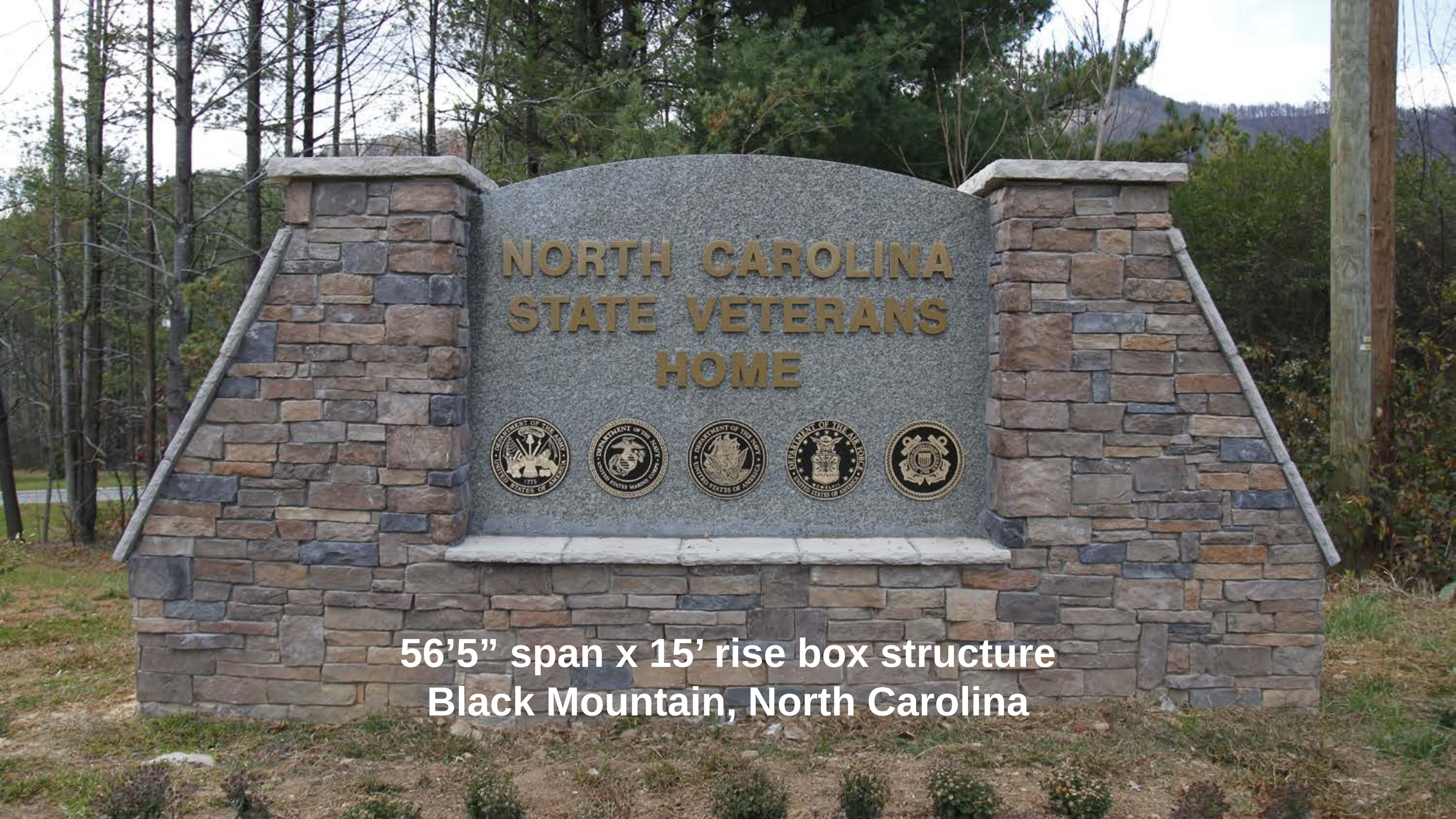
- Small Span Rural Crossings
- NC State Veterans Home – Black Mountain, NC
- Emergency Bridge Replacement – Cape Girardeau County, MO
- Heavy Loads – NM, AK, IN, NE

Lincoln County, Colorado


TEREX


Weld County, Colorado


Vantage, Washington

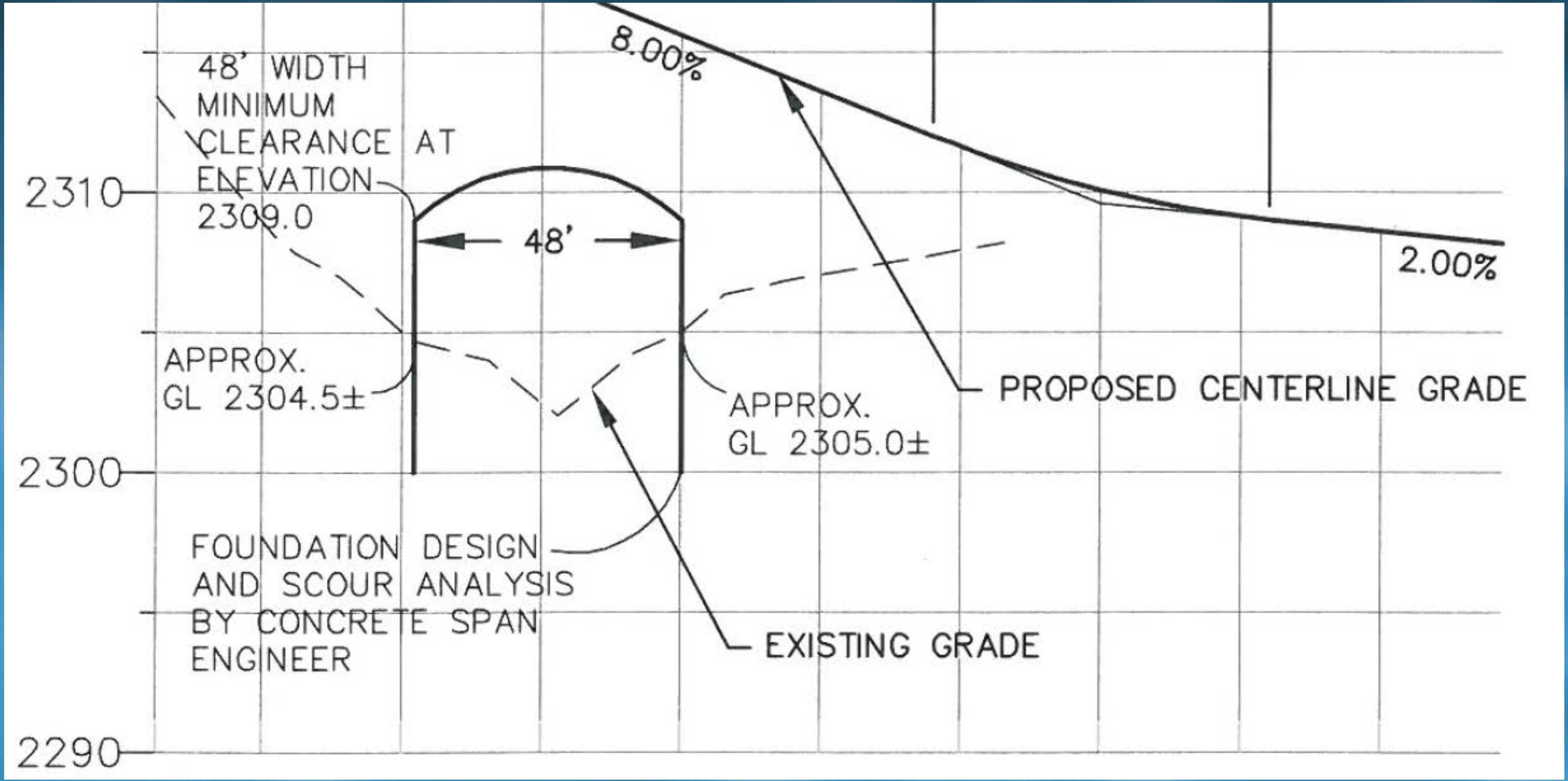


56’5” span x 15’ rise box structure
Black Mountain, North Carolina

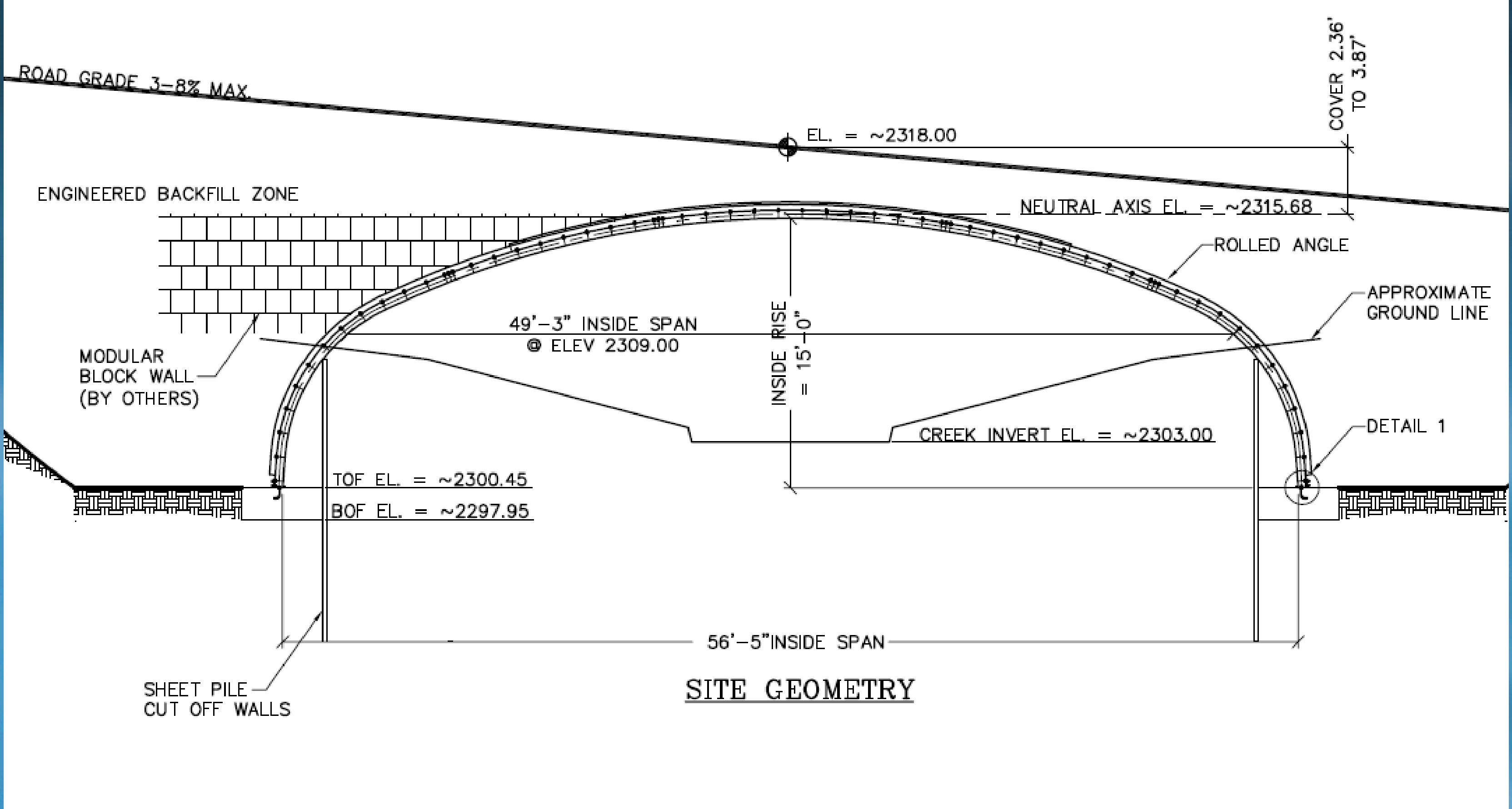
Design Requirements

- New road to access new facility
- ~15' distance from creek invert to road
- 48' min clear span at 6' above creek invert
- Creek 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



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%)**


MID-EXTEND

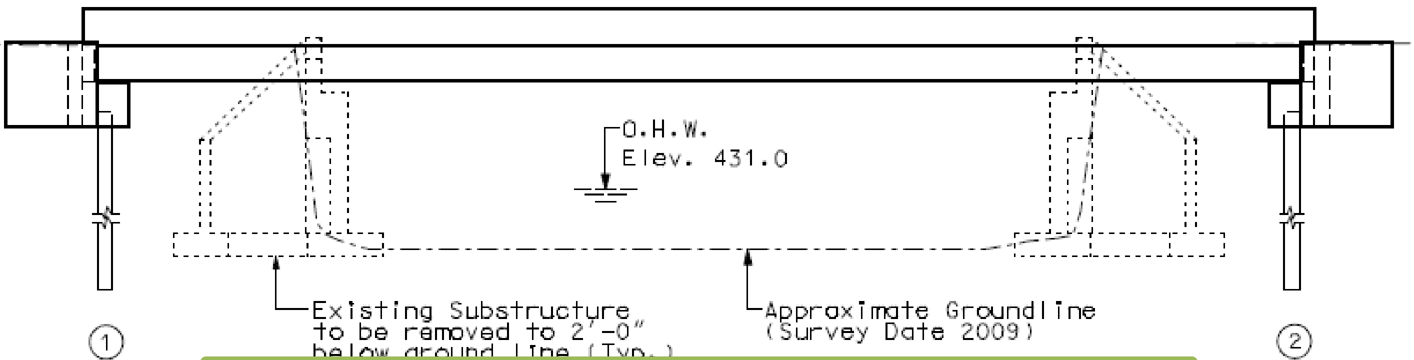

WATER

US61 Over Buckeye Creek
Cape Girardeau County, Missouri

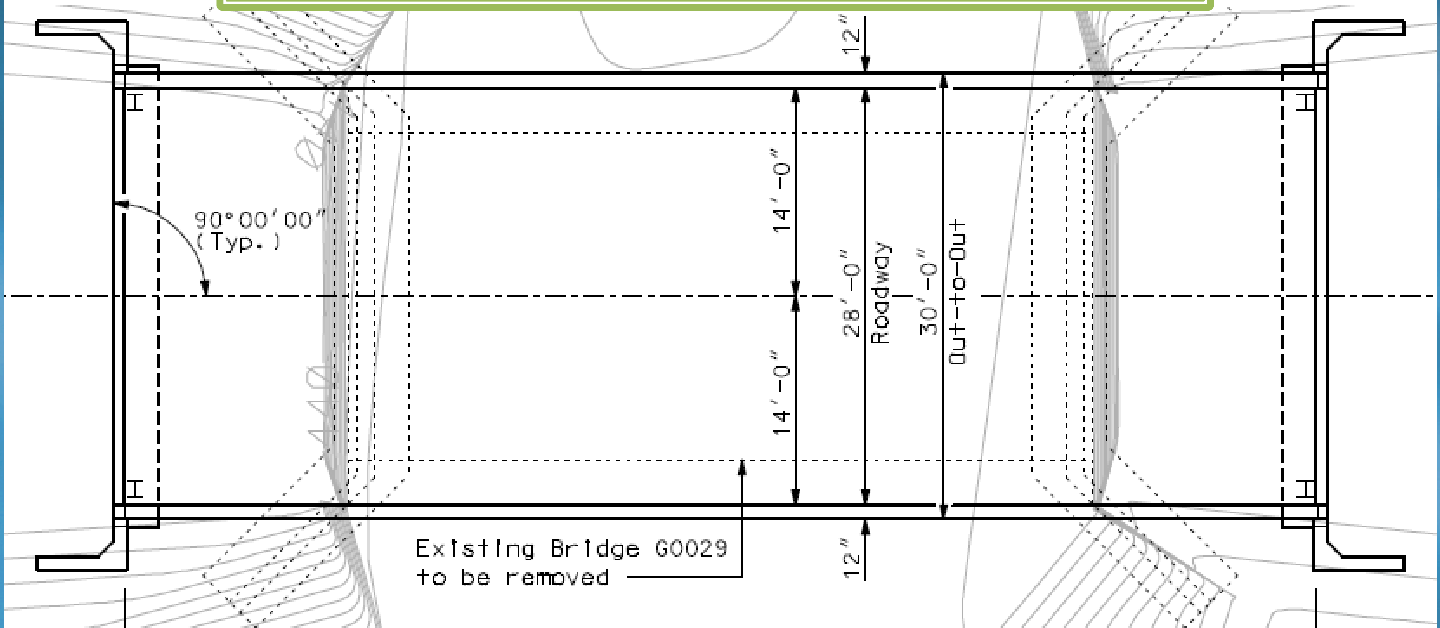
Twin Custom Box Structures
30’8¼” span x 11’7½” rise

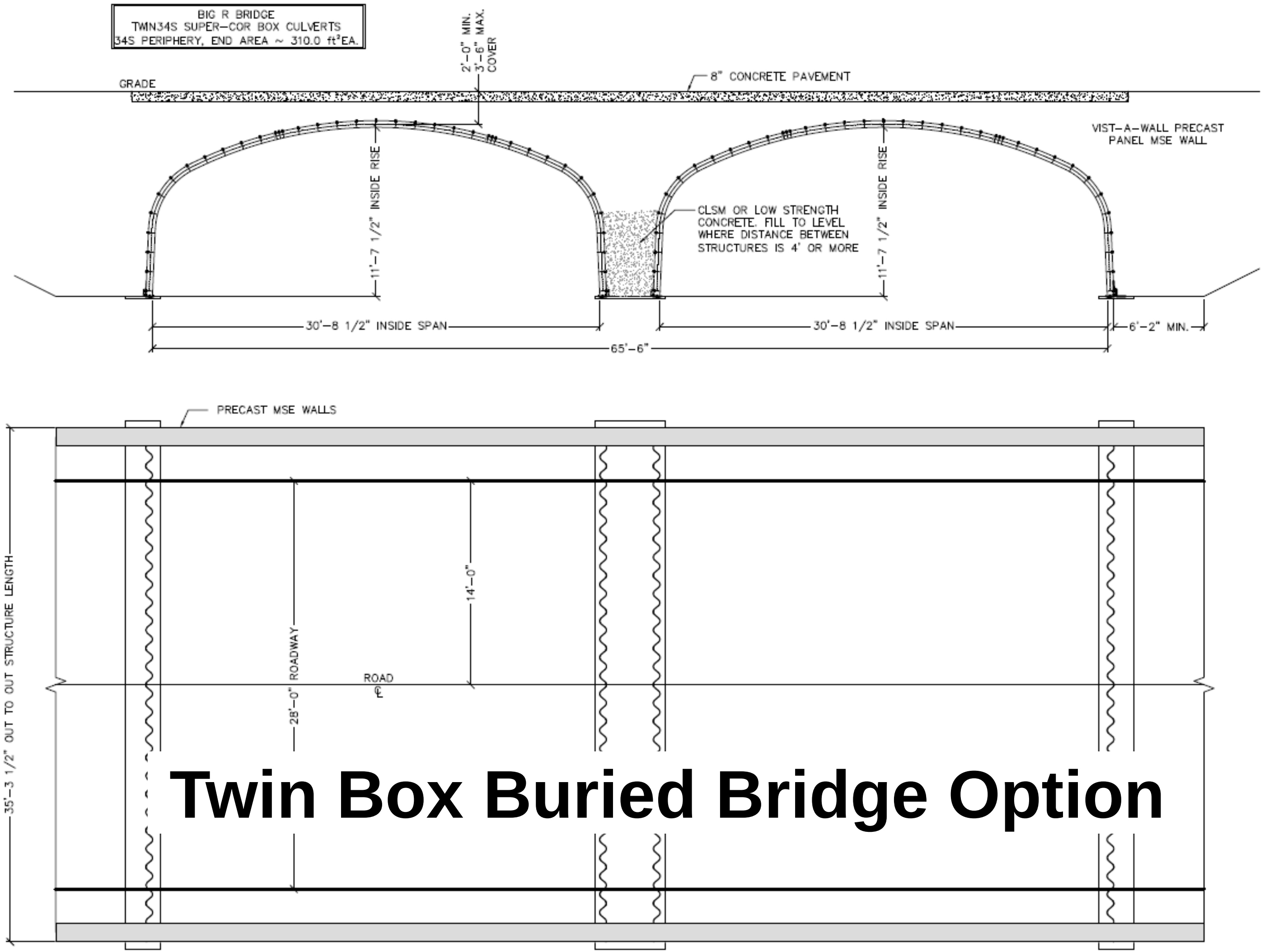
Design Requirements

- Part of Missouri Safe & Sound Program
- First design-build project in Cape Girardeau County
- Emergency replacement for old steel truss bridge - critical detour route for construction on nearby I-55
- Accelerated Bridge Construction
- Hydraulic requirements (flow area)



Original Concept: 80' Span Precast Bridge





Twin Box Buried Bridge Option

Structure Comparison

Conventional Precast Plank 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.

Heavy Loads

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

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


Fort Knox Gold Mine
Fairbanks, Alaska
1.8m lbs. Mining Shovel, 46 ft span
CAT

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

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

Thank You!

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