Bottomless Culverts 101

Presented By:
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Bridge Consultant
Alabama/Florida panhandle
Agenda

- Introduction
- Types of Bottomless Culverts
- Applications & Uses
- Siting Considerations
- Case Studies/Project Examples
- Questions/Open Discussion
Bridges & Structures, Stormwater Management, Pipe, Erosion Control and Retaining Walls
Common Types of Structure

CULVERT

PRECAST PLATE

BRIDGE AT-GRADE

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What is a “Bottomless Culvert”? 

“Bottomless Culverts are three-sided structures that use the natural channel for the bottom. These structures could be used to convey flows from one side of a highway to the other. As such, they are an environmentally attractive alternative to box, pipe, and pipe arch culvert designs.” - FHWA
Types of “Bottomless Culvert”

• Concrete
• Structural Plate (Aluminum & Steel)
ALDOT Approved

SECTION 841 – STRUCTURAL PLATE FOR PIPE, PIPE-ARCHES AND ARCHES

SECTION 531 – CORRUGATED METAL STRUCTURAL PLATE PIPE, ARCH PIPE, AND ARCH CULVERTS
Lightweight, Bolted Plate Construction

Freight economy

Efficient assembly

Lift and set in place

Handles highway loading
# Structural Plate Shapes

<table>
<thead>
<tr>
<th>Shapes</th>
<th>Sizes = Span x Rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Round</td>
<td>5’ to 50’-6″</td>
</tr>
<tr>
<td>Vertical Ellipse</td>
<td>4’-8″ x 5’-2″ to 25’ x 27’-8″</td>
</tr>
<tr>
<td>Underpass</td>
<td>12’-2″ x 11’-0″ to 20’-4″ x 17’-9″</td>
</tr>
<tr>
<td>Pipe-Arch</td>
<td>6’-1″ x 4’-7″ to 20’-7″ x 13’-2″</td>
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<tr>
<td>Horizontal Ellipse</td>
<td>7’-4″ x 5’-6″ to 14’-11″ x 11’-2″</td>
</tr>
<tr>
<td>Arch (single radius)</td>
<td>6’ x 1’-10″ to 54’-4″ x 27’-2″</td>
</tr>
<tr>
<td>Arch (2-radius)</td>
<td>18’-5″ x 8’-4″ to 50’-7″ x 19’-11″</td>
</tr>
<tr>
<td>Low-Profile Arch</td>
<td>19’-5″ x 6’-9″ to 45’-0″ x 18’-8″</td>
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### Additional Shapes

| High-Profile * | 20’-1″ x 9’-1″ to 35’-4″ x 20’-0″ |
| Horizontal Ellipse | 19’-4″ x 12’-9″ to 37’-2″ x 22’-2″ |
| Pear-Arch      | 23’-11″ x 23’-4″ to 30’-4″ x 25’-10″ |
| Pear          | 23’-8″ x 25’-5″ to 29’-11″ x 31’-3″ |
| Box Culvert   | 8’-9″ x 2’-6″ to 35’-3″ x 13’-7″   |
| Elliptical/Circular Arch | 12’ to 102’ |
| H-20 Bridge ** Pedestrian ** | spans up to 300’ spans up to 300’ |

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Structural Plate Durability

Controlling Factors
- pH
- Resistivity
- Hardness

When to Use Steel or Aluminum?

STEEL:
- $6.0 \leq \text{pH} \leq 10.0$
- Resistivity > 2,500 ohm-cm
- Hardness > 300 mg/L

ALUMINUM:
- $4.0 \leq \text{pH} \leq 9.0$
- Resistivity > 500 ohm-cm
- Hardness < 300 mg/L
Structural Plate Durability – Galvanized Steel

Plate and CSP estimator on website

Based on CALTRANS/AISI studies of CSP

Buried bridges designed without inverts
  Improves overall durability
  Eliminates potential invert corrosion
  Quality backfill aids in durability

Steel structural plate – 50% more galvanized coating

Post applied coatings aid in extending service life
  Polymers, Asphalt, Concrete Paving, etc.

Impermeable membranes over structure
  Minimize water migration
  Shed de-icing chemicals

**NCSPA.org** for Service Life Calculator

www.ContechES.com
CONCRETE – CON/SPAN and BEBO
Concrete Arches
Modular Components

PRECAST FOUNDATION

PRECAST ARCH UNIT

PRECAST HEADWALL

PRECAST WINGWALL

TWIN LEAF CONSTRUCTION

CURVED ALIGNMENT

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Applications for a Bottomless Culvert

- Stream Crossings
- Environmental/Wetland Crossings
- Highway
- Airport
- Railroad
- Pedestrian Crossings
- Golf Cart Underpasses
- Mining
- Relining Existing Bridges and Culverts
- Commercial Applications
Why Use a Bottomless Culvert?

- Hydraulic Advantage: Single Span vs Multiple Barrels
- Environmental: Clear Span, Zero to Temporary Impact
- Stream Ecology: Aquatic organism passage (AOP), Fish Passage
- Maintenance

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“I need to span a stream and use a bottomless culvert in order to avoid a Corp permit. The stream is 10 ft wide. I need a 10 ft span bottomless culvert.”
You must determine what regulatory agency is driving the permitting? (US Army Corps of Engineers, US Fish & Wildlife, etc.) What are their requirements?

US Army Corps of Engineers

Nationwide Permit

Individual Permit

U.S. Fish & Wildlife Service

Endangered Species

Threatened & Endangered Species
Typical Stream Cross-section

- Extreme High Water (Channel Width) 10 ft
- Normal High Water
- Normal Flow
- Stream Width
- Upper Bank
- Lower Bank
Information Available on our Website

- Waterway Area Charts for all Plate & Precast Structures
- Hydraulic Coordinates for all Plate & Precast Structures
- DYOB (Design Your Own Bridge) Tool
- Links to HEC-RAS & FHWA's HY8
- Hydraulic Tools Program
- Case Studies
- Brochures
- Standard Details
- Specifications
Building Blocks to a successful Project

Solution Development

Design Support

Installation

DYOB® Design Your Own Bridge

To get started, choose a structure type:

- Aluminum Box Culvert
- MULTI-PLATE SUPER-SPAN
- CON/SPAN BEBO
- U.S Bridge Continental

DYO ALBC
DYO Plate
DYO Precast
DYO Truss

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Photo Simulation

- Great tool to help promote your project.
- Need several high resolution photos for the site taken from multiple angles.
- Allow 2 week turnaround
- Plate, Precast & Truss solutions available
**Geotechnical Investigation**

- Geotechnical investigation is required for a foundation design on all bottomless culverts.
- Get the Geotechnical Investigation/Report done early!
- The geotechnical engineer shall determine the number and location of the borings required.
- For Conventional Spread Footing, we would like to see the Nominal Bearing Resistance per LRFD, or at a minimum, the Allowable Bearing Capacity (must specify if bearing is net or gross). We will also like to see the coefficient of friction between the footing and subgrade listed in the report.
- For Pile Foundations, we will require a recommendation from the geotechnical engineer for the pile type and size. (e.g Steel H-Pile HP 14x73, 90 tons/pile) We will also require the vertical and lateral capacities of the piles.
- In the geotechnical report, include the elevations on the boring logs. Include the water table elevation and bearing strata elevation.
- Generally, for our structures, we allow up to 1” max settlement or ½” differential settlement.
- If our plate structure is to be used, we recommend the geotech provide the pH and Resistivity of the soil and water if spanning a stream.
Foundations

Conventional Spread Footings

- Cast-In-Place Concrete
Foundations

Conventional Spread Footings

- Express Foundations
MidCity Huntsville – Top Golf
Huntsville, AL

MidCity

- 100-acre mixed-use community
- $350 million redevelopment
- 345,000 SF specialty retail
- 200,000 SF high-tech office
- Over 900 residential units
- 150-room boutique hotel

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MIDCITY HUNTSVILLE – TOP GOLF
CONSPAN – 28’-0” Span x 9’-0” Rise
Express Foundations: 8’ x 2’ units, 4’-6” x 2’ wings
MidCity Huntsville – Top Golf
Huntsville, AL
Foundations

Deep Foundations

• Piles, Drilled Shafts, Etc
Scour Analysis

- The project engineer (engineer of record) is responsible for performing a scour analysis.

- Methods of evaluating scour:
  - HEC 18 – Evaluating Scour at Bridges
  - HEC 20 – Stream Stability at Highway Structures

- Methods of scour countermeasures:
  - HEC 23 – Countermeasure Design for Bridge Scour and Stream Instability
  - ArmorFlex, Ajacks, Rip-Rap, Sheeting, etc.
Figure 1.1: Flowchart for scour and stream stability analysis and evaluation.
Scour Countermeasures

• Rip Rap
Scour Countermeasures

• AmorFlex
Scour Countermeasures

- AJacks
CASE STUDIES
Project Case Study
Auburn Technology Parkway – Thistle LN to Riley ST
Auburn, AL
PROJECT INFORMATION

- **Owner** – City of Auburn
- **Project Engineer** – City of Auburn Engineering Department (Patrick Slaughter)
- **Geotechnical Engineer** – Carmicheal Engineering
- **Contractor** – D&J Enterprises
- **Funding** – City
- **Construction**: June 2013
- **Product**: Contech ConSpan 0740 (54 LF of ConSpan 40’ x 10’)

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Auburn Technology Park West  
Auburn, AL

Design Challenges

• The City of Auburn was under a deadline to get the new roadway completed in their industrial park.

• A creek crossing was required. Original plan was to use box culverts. It was later determined the stream was a Jurisdictional Stream. Permitting could possibly prevent the City from meeting a completion date.

• Funding for the project was through an ALDOT Industrial Grant.
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Auburn Technology Park
Auburn, AL
Auburn Technology Park
Auburn, AL
“We, along with the Contractor, were impressed with the quick, one day installation time of the precast CON/SPAN structure,” stated Jeff Ramsey, City Engineer/Public Works Director with the City. “The Contractor had a significant amount of fill material to move from one side of the stream to the other, but due to stream and wetland impacts, could not accomplish this work until the precast structure was installed. Once installed, the Contractor was able to complete the remaining earthwork on the project very quickly.”

Contractor Information
- D&J Enterprises Inc.
  Auburn, AL
- First ConSpan installation
- Contractor chose to go with cast-in-place foundations instead of our Express Foundations.
- The Contractor had allocated five days for the installation of the bridge in their bid, but much to their surprise, it was completed in just one day! All nine precast arch units were set in place via crane by noon. After lunch, two headwalls and four wingwalls were installed, the joints were sealed and the keyway was grouted. The installation was completed in full by 5:45 pm.
Project Case Study
Rivercrest Drive over Logan Martin Lake in St. Clair Co. - ACBRZ59784-ATRP(012)
PROJECT INFORMATION

- **Owner** – St. Clair County (Dan Dahlke, County Engineer)
- **Project Engineer** – CDG Engineers (Marc Thompson, PE)
- **Geotechnical Engineer** - CDG Engineers (Allen Yates, PE)
- **Contractor** – Winston Contracting (Benjy Reeves, Superintendent)
- **Plate Assembly** – Plate Erectors (Bob Wright)
- **Plate Structure** – Contech Engineered Solutions (Tod Green, PE - Bridge Consultant)
- **Funding** – ALDOT ATRIP
- **Construction**: January 2016 – April 2016
- **Product**: Contech BridgeCor 36S (26’ Span x 14’-11” Rise), 8 Ga
Existing Bridge on Rivercrest Dr.
St Clair County – Pier 59/Rivercrest Drive (ALDOT Project)
Cropwell, AL
Contech BridgeCor 36S Structure
(26’ Span x 14’-11” Rise),
8 Ga, 40’-3” Total Length

St Clair County – Pier 59/Rivercrest Drive
Cropwell, AL
FOUNDATIONS INSTALLED IN DRY CONDITIONS

- Cast-In Place Concrete Foundations
  - 6’-4” wide x 2’-6” deep
  - Based on 3000 psf Allowable Soil Bearing Capacity
SOIL IMPROVEMENTS REQUIRED

- Low-consistency fill and Alluvium soils present to a depth of 3 ft. to 8 ft. below proposed bottom of footings.
- Over-Excavation not allowed by ALDOT.
- Helical Piles or HDP Injection recommended
- Contractor chose to use High Density Polyurethane Injection to improve bearing capacity
  - Rapid cure time.
  - Can support full loads after 15-minutes,
  - Achieves full strength after 24-hours
- **Plate Assembly**
  - 1 ½ days to assemble and slide into place
  - Plate Erectors assembled the plates and Winston Contracting pulled the plate structure into place.
St Clair County – Pier 59/Rivercrest Drive
Cropwell, AL
Questions?

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