Sioux City Iowa Utilizes HDD to Install Twin 36” Casings for Sanitary Sewer Siphons

Presented by...
Peter Merten, PE, HR Green, Inc.
and
David Reuter, PE, Underground Solutions

UCT Underground Construction Technology
International Conference & Exhibition January 30 – February 1, 2018
Ernest N. Morial Convention Center, New Orleans, Louisiana
Presentation Outline…

1. Problem Definition
2. Design Process
   a. Trenchless Technique Selection
   b. Profile Geometry & Pipe Material Selection
   c. Plan Approvals & Permitting
3. Construction
   a. Overview
   b. Work Site Logistics
   c. Aerial Insertion
   d. Keys to Success
4. Lessons Learned
**Problem Definition…**

Part of the “I-29 Segment 2 Utility Replacement Project”

- Owned by Sioux City, Iowa.
- New Siphon designed in 2013 & constructed in 2014.
- Replaces an existing Double Barrel Siphon located in IaDOT Right-Of-Way in the way of the highway expansion; specifically a bridge abutment.
- Located approximately 1,100-ft upstream of the original location.
Problem Definition…

FLOYD RIVER

ENTRY

800-ft

400-ft

500-yr

EXIT

6-ft

34-ft

120-ft

30-ft

60-ft
Problem Definition…

Subsurface Conditions:
• Missouri River alluvium.
• High groundwater table.
• Random layers of sand, clayey sand, and sandy clay overlain by fatty clay and man-made fill.
• Bedrock was not encountered.
Problem Definition…
Design…

Trenchless Technique Selection

Microtunneling (MT) Alternate
- 24” & 30” PVC or HDPE carrier pipes bundled into a single 72” steel pipe casing.
- Grouted annulus.
- Budget level EOPC $5.3 million.
- 9 months to one year to construct.

MT Constructability Issues
- Use the slurry method w/ closed face earth pressure balance tunnel boring machine (EPB-TBM).
- 60-ft deep bore pit shafts.
- Continuous dewatering.
- Pipe lubrication during jacking.
- At least one intermediate jacking station.
HDD Alternate
- Each carrier pipe is installed in its own casing pipe.
- Twin siphon casing pipes are installed in parallel horizontally and vertically.
- Grouted annulus.
- Budget level EOPC $2 million.
- 6 months to construct.

HDD Constructability Issues
- 36” casing pipe in 48” borehole.
- Requires a “maxi-rig” for the installation.
- Bend radius estimate eliminated steel and ductile iron pipe.
- PVC and HDPE were remaining choices.

Preferred Alternate!
Design...

Profile Geometry

Approximate Bore Path Length = 1,500 ft

Drill Entry / 11°

Drill Exit / 10°

Floyd River

Entry

Target Connection PT

Exit

Target Connection PT

R = 1,679 ft

R = 1,150 ft
It’s all about pipe stiffness!

- A pullback force of **235,000-lbs** was estimated requiring a pipe stiffness of approximately **224 psi**.
- Pipe stiffness, \( PS = \frac{2E}{3(DR-1)^3} \times 0.149 \)
  - \( E \) = Modulus of Elasticity of the pipe material, psi.
  - \( DR \) = Dimension Ratio of the pipe section; OD/tw.
  - HDPE has a modulus of elasticity = 100,000 psi.
  - PVC has a modulus of elasticity = 400,000 psi.
- Evaluation of the pipe material choices for identical installation and external loads resulted in:
  - For HDPE, a 36” DR13.5, **BUT**, a 42” DR9 is necessary to meet required inside casing diameter tolerance.
  - For Fusible PVC, a 36” DR21 is necessary and meets the inside casing diameter tolerance.
Pipe Material Selection

AWWA Standards:
- C905 FPVC
- C906 HDPE

- Key is the need for a minimum casing ID = 34” in order to slipline a 30” carrier pipe with an OD of 32” (2” tolerance).

- A 36” HDPE DR13.5 has an ID = 32.29” (Out of tolerance by 1.71”).
Design…

Plan Approvals & Permitting

Two key agencies from which approval was required:
• Union Pacific Railroad (UPRR) ~ had most stringent criteria:
   AREMA (AREMA 2013) Manual for Railway Engineering Sections 5.3 & 5.6.
  • Pipe External Load Analysis.
  • Pipe Axial Stress Analysis.
  • Hydro-Fracture Risk.
  • Borehole Collapse Potential.
  • Work Site Logistics.
  • Machine Performance Prediction.
  • Mud Circulation, Volume & Disposal.
  • Operation & Maintenance.
**Design...**

**Plan Approvals & Permitting**

- **Iowa Department of Natural Resources (DNR):**
  Required the siphon pipelines be cased for the segments located beneath the river; and
  Required and obtained a variance for the use of trenchless technology.

- Submittal documentation structured using AREMA topic format.
  Included evaluation of worksite logistics, rig compatibility, hydro-fracing, borehole collapse, mud circulation/volume/disposal.

- With slight adaptation, the documentation prepared for the UPRR was submitted to the DNR for review and approval.
General Contractor:
- Minger Construction of Chanhassen, Minnesota.

Directional Drill Subcontractor:
- Gabe’s Construction of Sheboygan, Wisconsin.

Equipment:
- American Augers DD330 Maxi Rig w/ 330,000 lbs of thrust.
- Mud Technology MCT 1000 Recycling System w/ Tulsa TT 660 Mud Pump.
- Pilot hole drilled with a wireline location system.
Construction...

Overview

Drilling Process:
• 10-5/8” Pilot Hole.
• Reaming passes of 30”, 42”, and 52” - using a “fly cutter”.
• Final hole conditioning swab with ball reamer prior to pull-in.
Construction...

Overview

30” FPVC Carrier Pipe in 36” FPVC Casing:
• Full length of carrier & casing fused prior to pull-in.
• Carrier pipe was pre-loaded into casing.
• Water ballasted.
• 7 hour pull-in time w/ 130,000 lb max recorded pull force.
• Annular space grouting.

24” FPVC Carrier Pipe in 36” FPVC Casing:
• Full length of carrier & casing fused prior to pull-in.
• Carrier pipe was pre-loaded into casing.
• Water ballasted.
• 7.25 hour pull-in time w/ 140,000 lb max recorded pull force.
• Annular space grouting.
Construction… Work Site Logistics

- Bore Path – 1,140 LF
- Pipe String Layout
- Pipe Insertion Location
- Floyd River
- Drill Rig Setup Location
During Design

- Conceptualize drill operation.
- Prepare a worksite layout plan.
- Set expectations for equipment & facility space allocation.
- Identify location to fuse and string pipe.
- Get City & DOT buy-in.
Construction…

Work Site Logistics

During construction

• Does the design plan work?
• Modifications based on contractors work plan.
• Discovery of unknowns?
• Getting the right equipment & support facilities placed at the site.
• Continuous coordination with City & DOT.
• Execution of the plan.
Construction… Aerial Insertion
Construction…

Aerial Insertion
Construction…

Keys to Success

- Space was available for a maxi-rig operation.
- Ability to fuse and layout the full length of pipe.
- Carrier pipe pre-loading.
- Closing of I-29 on-ramp during pull-in.
- Aerial insertion.
- Water ballasting.
- Communication.
Lessons Learned…

Defensible Constructible Design
  - *Use AREMA as a template!*

Pipe Material Selection
  - *The right pipe for the right application…its all about pipe stiffness!*

Worksite Logistics
  - *Designers need to do their homework!*

Design-Build
  - *Designer-Contractor collaboration!*
Lessons Learned…

Profile Geometry
- Direct correlation with pipe axial stress...beware of the capstan effect!

Field Adjustments / Modifications
- Construction means & methods flexibility!

Communication
- Communicate-communicate-communicate-communicate!
QUESTIONS FROM THE AUDIENCE
Ask away…
Thank You!

Peter Merten, MSCE, PE, M.ASCE, Project Engineer
16020 Swingley Ridge Road, Suite 205,
Chesterfield, MO 63017
314-249-9436, packdog60@gmail.com

David Reuter, PE, Vice President of Sales, Western Region
6810 Roe Avenue, Prairie Village, KS 66208
816-518-5162, dreuter@undergroundsolutions.com