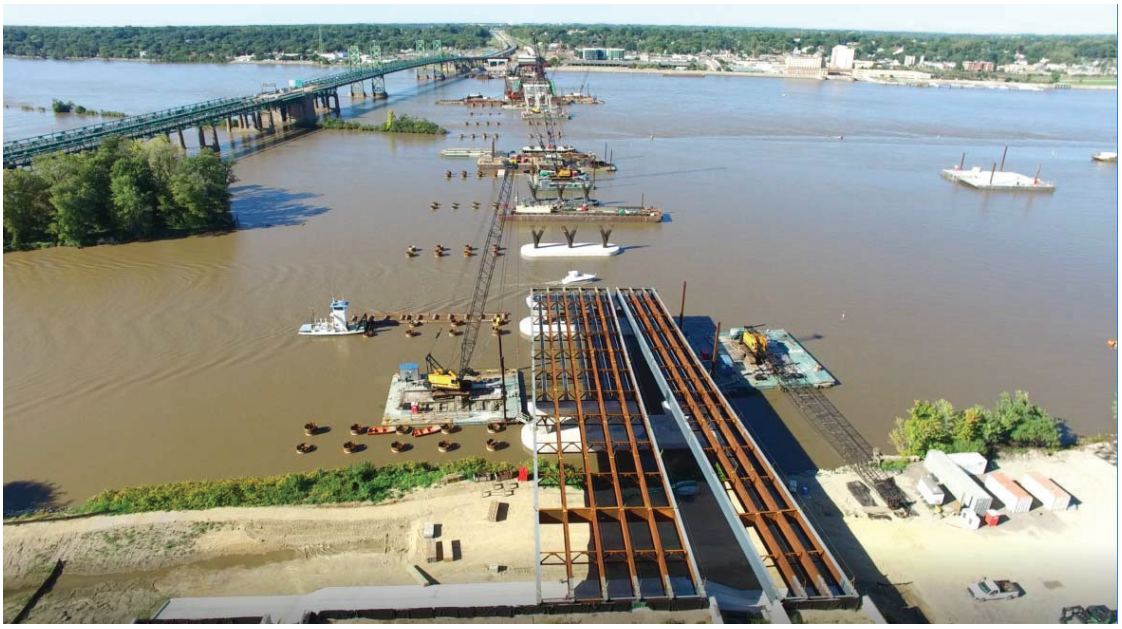
I-74 Concrete Drilled Shaft Installation – Quality Control Lessons Learned



Travis Konda, PhD, PE, SE

2018 Iowa Better Concrete Conference 2018, 08NOV18

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State-of-the-art Mississippi River Bridge

Project Leads

IOWA DOT

Illinois Department of Transportation

U.S. Department of Transportation
Federal Highway Administration

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Project Team – 198M Contract (River Bridge)

- Designer
  - Benesch – EOR
  - Hanson – Geotech
  - Modjeski and Masters – Arch Spans

- General Contractor - Lunda Construction ($322 M)
- Drilled Shaft Sub – Michels Foundation
- Concrete Supplier – Hahn Ready Mix

- CEI – HNTB
- AMEC - GEC

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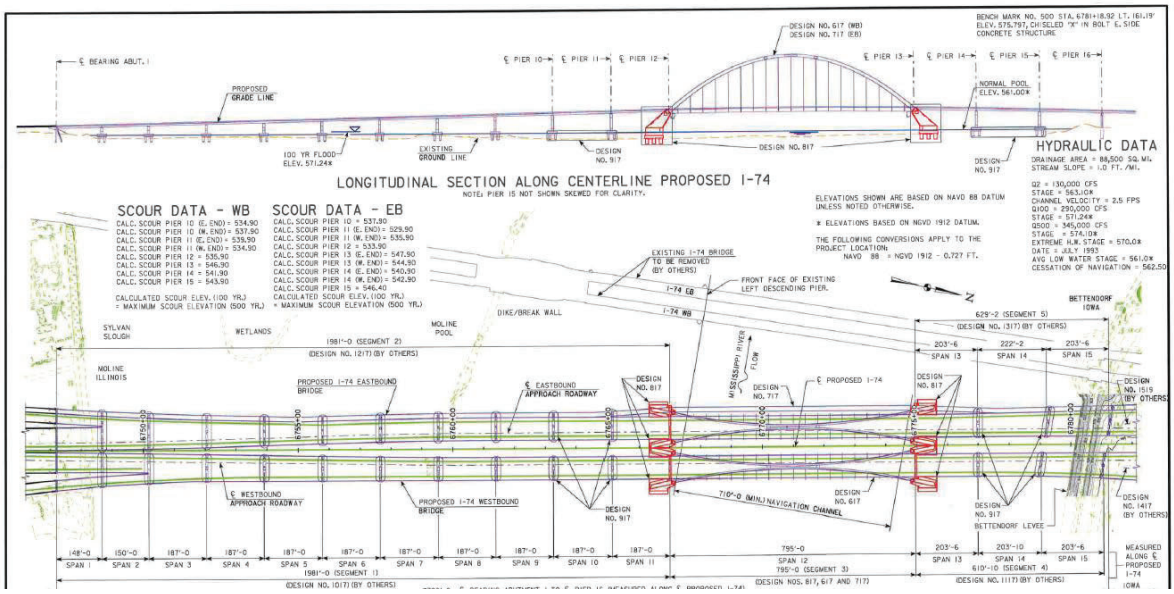
Project Scope – 198M Contract (River Bridge)



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Shaft Installation – 198M Contract (River Bridge)

- 239 Production Drilled Shafts
- Water Shafts
  - 196 – 7 ft diameter (Approach Piers 2-11, 13-15)
  - 37 – 10 ft diameter (Arch Foundation Piers 12 and 13)
- Land Shafts
  - 6 – 10 ft diameter (Pier 16)

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Shaft Installation – 198M Contract (River Bridge)

- Iowa DOT Specifications 2433 Concrete Drilled Shaft
- Contract payment
  - Drilled shaft, length installed (included concrete)
  - Rebar – lbs in cage, contract rebar
- Acceptance by CSL – Iowa DOT

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Drilled shaft Installation - CEI Tasks

- Continuous inspection, they are out there, we are out there
- Top of rock determination
- Drilling progress – document what is coming up
- Determine shaft depth, hole preparation
- Concrete placement
- Drilled shaft report
  - Time line
  - Depth
  - Yield
- Posting for payment

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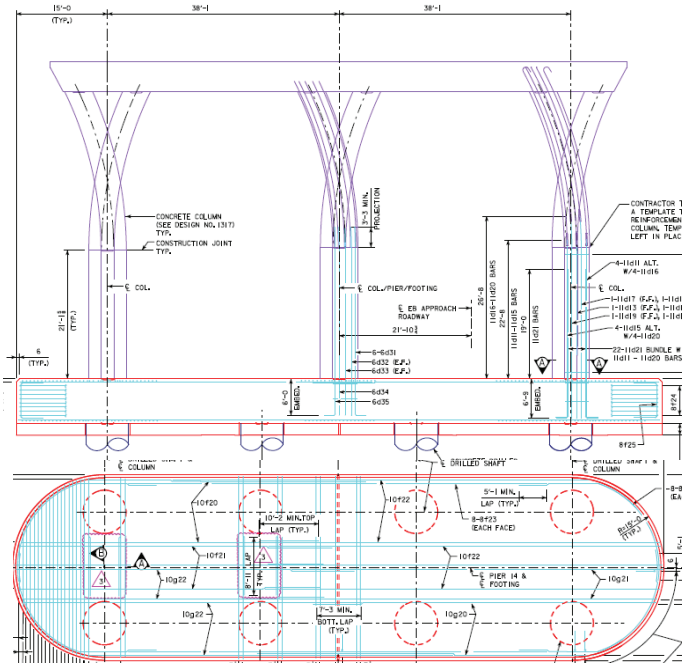
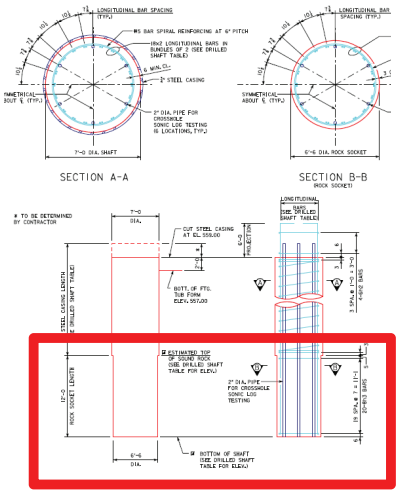
Approach Piers/Foundations



7 ft Drilled Shafts



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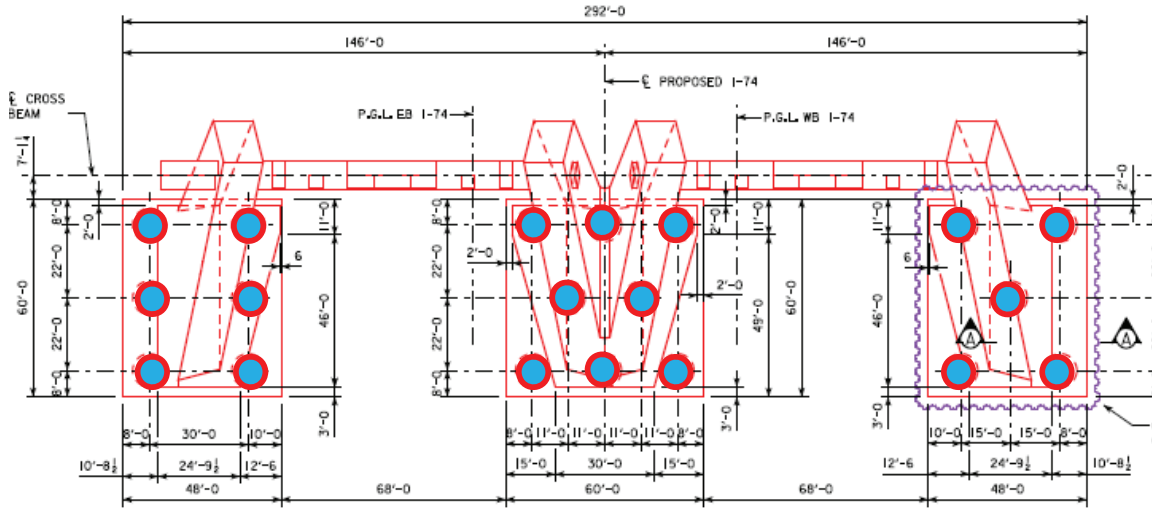
Arch Pier/Foundations



PLAN - PIER 12

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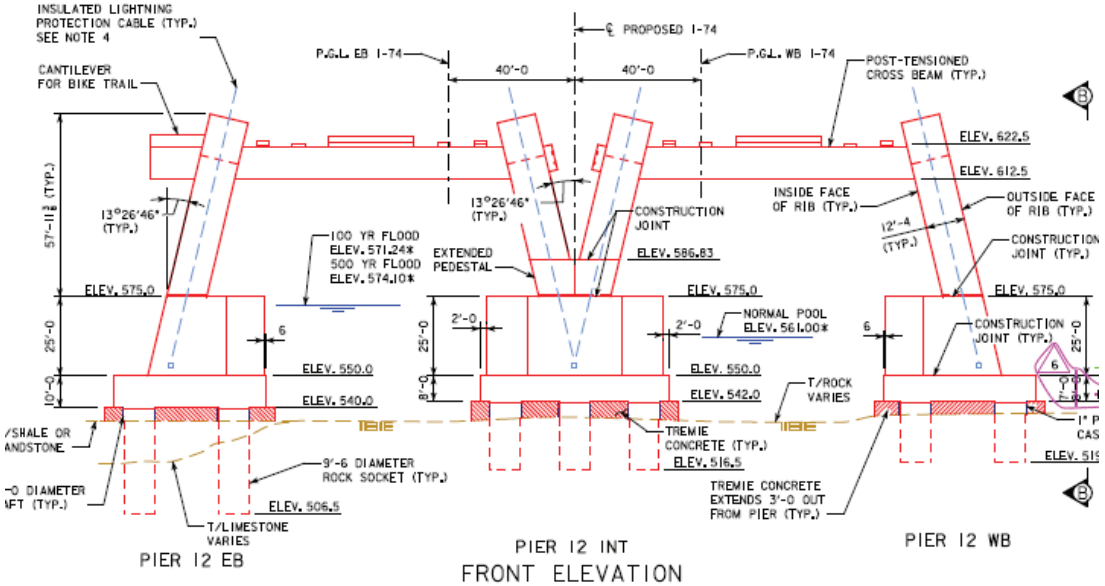
Arch Pier/Foundations



FRONT ELEVATION

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Drilled Shaft Mix – D-57-C15

- Mix is standard Iowa DOT mix for Drilled Shafts
- D – Structural mix – Typically Drilled shafts
- 57 – 50/50 split of aggregate
- C15 – 15% Class C fly ash replacemeny
- 709 lbs of Cementitious materials
  - 603 lbs Cement Type I/II
  - 106 lbs Class C Fly Ash
  - Reference SS 2433, 2403
  - Reference IM 401, 403, 529

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Drilled Shaft Mix – D-57-C15

- Aggregate Gradation
  - Coarse (1404 lbs)

	1 1/2"	1"	3/4"	1/2"	3/8"	#4	#8	#200	Comply
				95-100			0-10		Y/N
DSRO30C	100	100	100	100	81	31	9.1	1.1	Y

  - Fine (1434 lbs)

Fine	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200	Comply
		100	90-100	70-100		10-60			0-1.5	Y/N
DSRO30S		100	95	88	78	49	14	2.4	0.4	Y

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Drilled Shaft Mix – D-57-C15

- Water (300 lbs)
  - Target w/c ratio = 0.423
  - Max w/c ratio = 0.45
- Slump 8” +/- 1 ½”
  - Mira 62 Mid Range Water Reducer (3.5 oz/cwt)
  - Recover (8.0 oz/cwt)
- Air 7% +/- 1 ½%
  - Daravair 1400 (1.5 oz/cwt)

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Drilled Shaft Mix – D-57-C15

- Design strength (28 days)
  - 7 ft diameter - f'_c = 4000 psi
  - 10 ft diameter - f'_c = 5000 psi
  - Ave cylinder breaks = 6880 psi
- Coring strengths
  - 2000 psi (anomalies)
  - 8500 psi +

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Concrete Delivery

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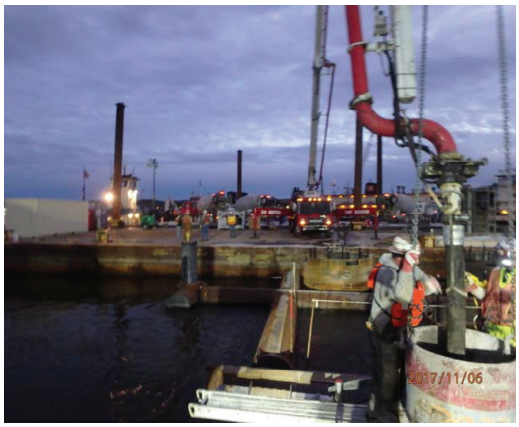
Concrete Placement



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Concrete Placement

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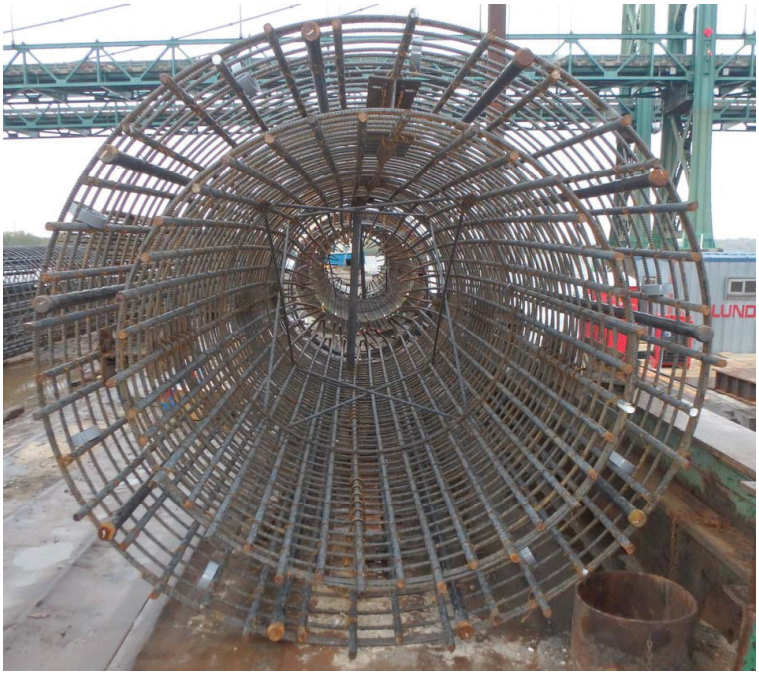
Concrete Placement – Reinforcing Restrictions



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Drilled Shaft Reinforcement

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Drilled Shaft Reinforcement

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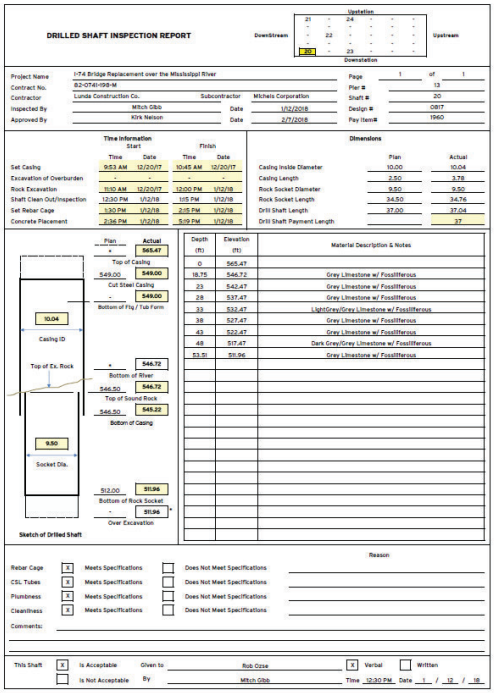
Drilled Shaft Reports – DSR



DRILLED SHAFT INSPECTION REPORT

Project Name	I-74 Bridge Replacement over the Mississippi River
Contract No.	82-0741-198-M
Contractor	Lunda Construction Co.
Subcontractor	Michels Corporation
Inspected By	Mitch Gibb
Approved By	Kirk Nelson
Date	1/12/2018
Page	1 of 1
Pier #	13
Shaft #	20
Design #	0817
Pay Item #	1960

Time Information

	Start Time	Start Date	Finish Time	Finish Date
Set Casing	9:53 AM	12/20/17	10:45 AM	12/20/17
Excavation of Overburden	-	-	-	-
Rock Excavation	11:10 AM	12/20/17	12:00 PM	1/12/18
Shaft Clean Out/Inspection	12:30 PM	1/12/18	1:15 PM	1/12/18
Set Rebar Cage	1:30 PM	1/12/18	2:15 PM	1/12/18
Concrete Placement	2:34 PM	1/12/18	5:19 PM	1/12/18

Dimensions

	Plan	Actual
Casing Inside Diameter	10.00	10.04
Casing Length	2.50	3.78
Rock Socket Diameter	9.50	9.50
Rock Socket Length	34.50	34.76
Drill Shaft Length	37.00	37.04
Drill Shaft Payment Length		37

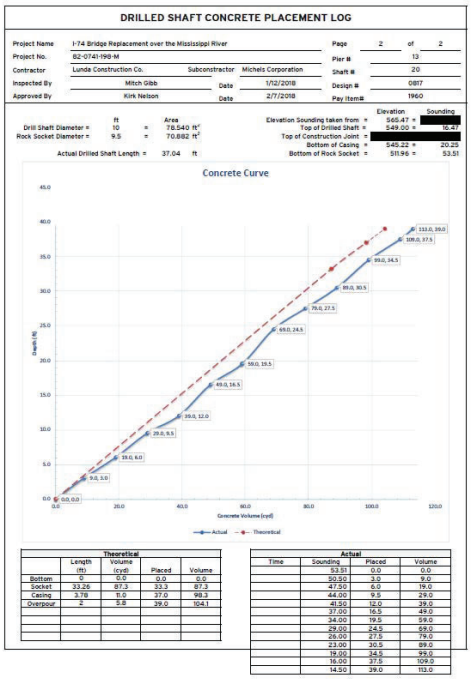
Sketch of Drilled Shaft

Depth (ft)	Elevation (ft)	Material Description & Notes
0	565.47	
18.75	546.72	Grey Limestone w/ Fossilferous
23	542.47	Grey Limestone w/ Fossilferous
28	537.47	Grey Limestone w/ Fossilferous
33	532.47	LightGrey/Grey Limestone w/ Fossilferous
38	527.47	Grey Limestone w/ Fossilferous
43	522.47	Grey Limestone w/ Fossilferous
48	517.47	Dark Grey/Grey Limestone w/ Fossilferous
53.51	511.96	Grey Limestone w/ Fossilferous

Rebar Cage	X	Meets Specifications		Does Not Meet Specifications
CSL Tubes	X	Meets Specifications		Does Not Meet Specifications
Plumbness	X	Meets Specifications		Does Not Meet Specifications
Cleanliness	X	Meets Specifications		Does Not Meet Specifications

Comments:

TWs Shaft: X Is Acceptable; Is Not Acceptable. Given to: Rob Ozse. By: Mitch Gibb. X Verbal; Written. Time 12:30 PM. Date 1 / 12 / 18



DRILLED SHAFT CONCRETE PLACEMENT LOG

Project Name	I-74 Bridge Replacement over the Mississippi River			Page	2 of 2
Project No.	82-0741-198-M			Pier #	13
Contractor	Lunda Construction Co.	Subcontractor	Michels Corporation	Shaft #	20
Inspected By	Mitch Gibb	Date	1/12/2018	Design #	0817
Approved By	Kirk Nelson	Date	2/7/2018	Pay Item #	1960

	ft		Area
Drill Shaft Diameter =	10	=	78.540 ft²
Rock Socket Diameter =	9.5	=	70.882 ft²

Actual Drilled Shaft Length = 37.04 ft

	Elevation	Sounding
Elevation Sounding taken from =	565.47 =	
Top of Drilled Shaft =	549.00 =	16.47
Top of Construction Joint =		
Bottom of Casing =	545.22 =	20.25
Bottom of Rock Socket =	511.96 =	53.51

Concrete Curve

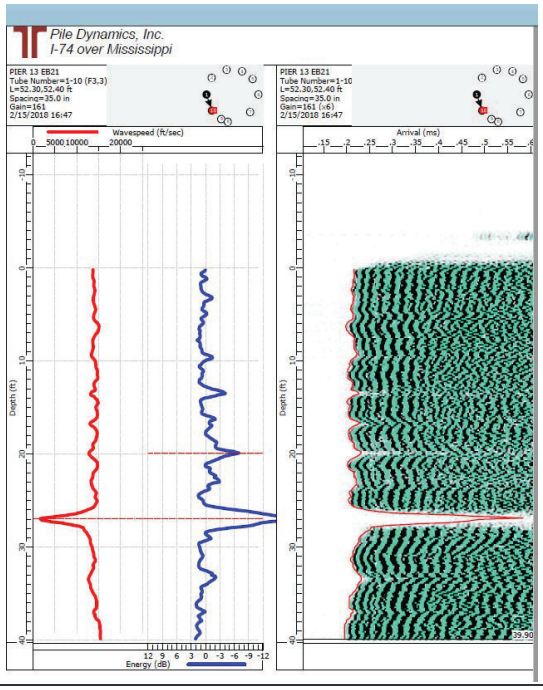
Theoretical

	Length (ft)	Volume (cyd)	Placed	Volume
Bottom	0	0.0	0.0	0.0
Socket	33.26	87.3	33.3	87.3
Casing	3.78	11.0	37.0	98.3
Overpour	2	5.8	39.0	104.1

Actual

Time	Sounding	Placed	Volume
	53.51	0.0	0.0
	50.50	3.0	9.0
	47.50	6.0	19.0
	44.00	9.5	29.0
	41.50	12.0	39.0
	37.00	16.5	49.0
	34.00	19.5	59.0
	29.00	24.5	69.0
	26.00	27.5	79.0
	23.00	30.5	89.0
	19.00	34.5	99.0
	16.00	37.5	109.0
	14.50	39.0	113.0

Acceptance of Shaft - CSL Testing



Location: EB Pier 13; Drilled Shaft 21; Core #3; Desired core length = 34'

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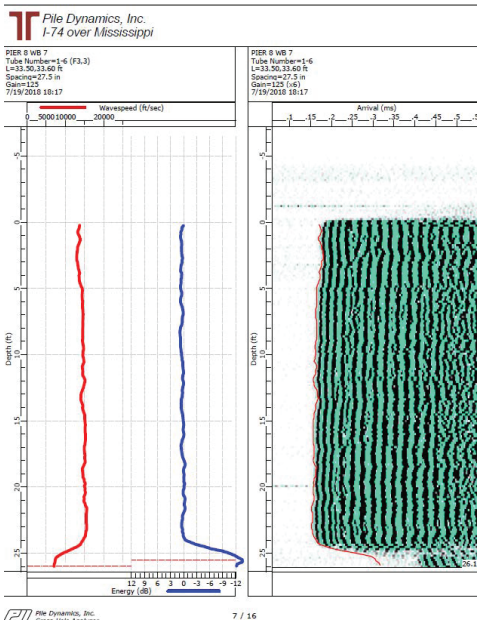
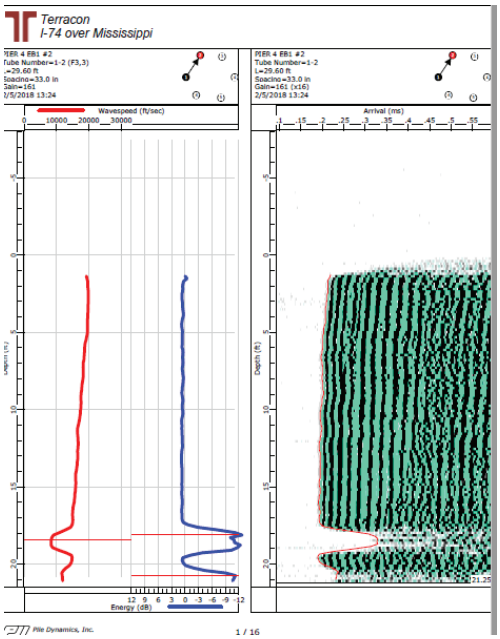
Remediation – Soft Toe



Remediation – Center core



Shaft Excavation

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Rigs and Equipment

- Contractor had three rigs working simultaneously, 8 to 14 hour days, working off of barges
- 2 – Liebherr L36 machines
- 1 - IMF AF300 machine

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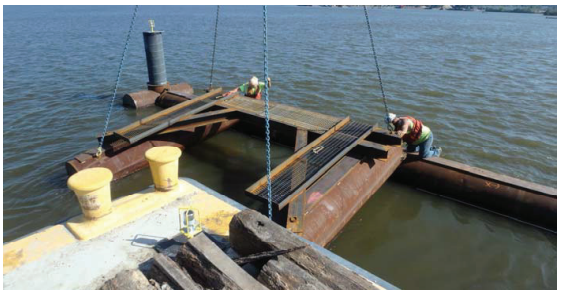
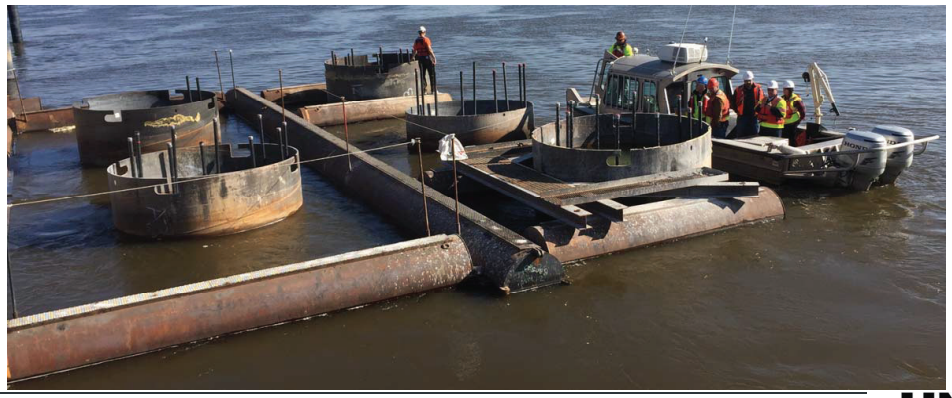
Supporting Operations





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Casing

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Casing

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Drilling Tools – Core Barrels and Augers

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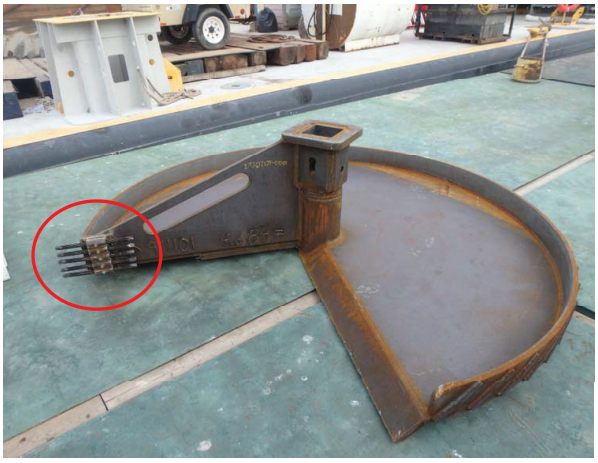
Drilling Tools – Flat Augers and Cleaning Pans



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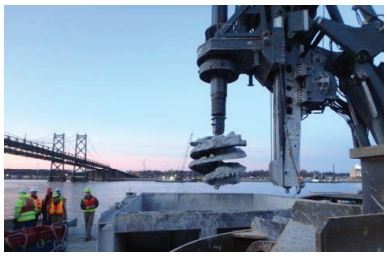
Drilling Tools



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Drilling Tools – Down Hole Hammers

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Drilling Tools – Down Hole Hammers

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Drilling Tools – Down Hole Hammers

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Establishing Top of Rock

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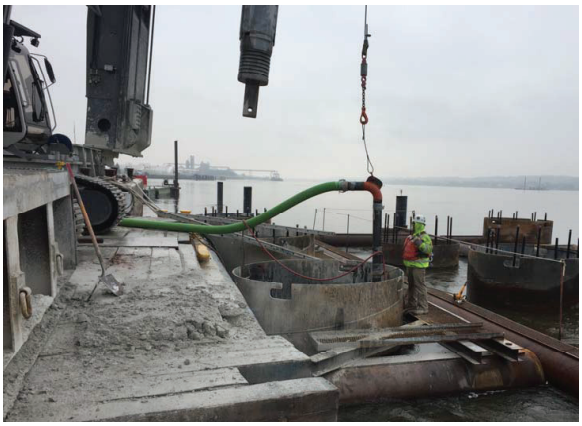
Hole – Final Preparation



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Environmental Requirements

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Environmental Requirements

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Harsh Conditions

Summary/Questions

- Shaft 1 – September 18, 2017
- Shaft 239 – July 20, 2018

- Thank you –
  - Iowa DOT
  - Illinois DOT
  - FHWA

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