



US 301 Section 2A

Construction Phase Downdrag Analysis

DeIDOT BDM Approach

Presented to: Mid-Atlantic Quality Assurance Workshop, February 14, 2018



AECOM 10/19/2016 10:14



OUTLINE

Project Background

Initial Design/Construction Sequence

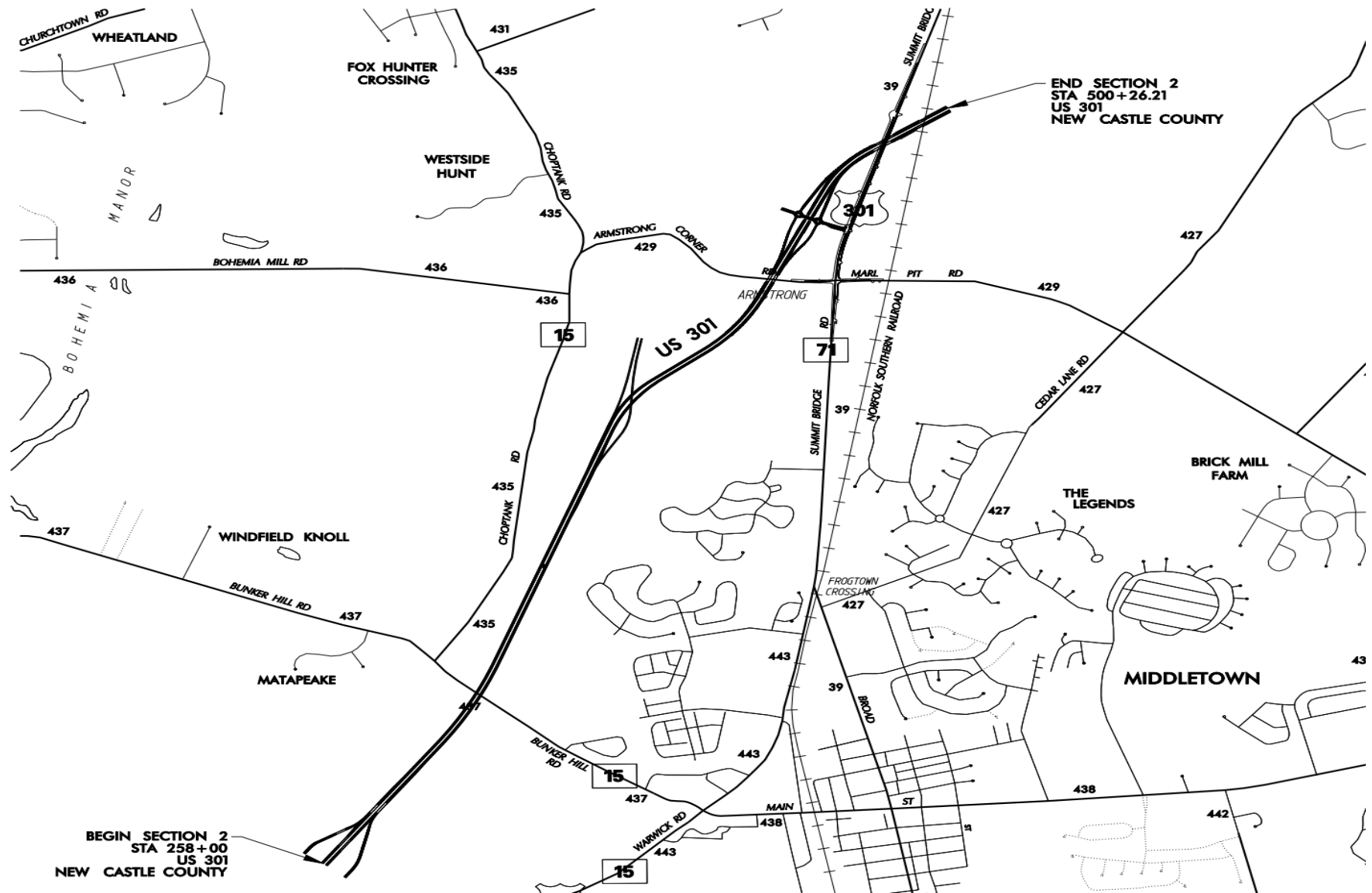
Alternate Downdrag Recommendation

Downdrag Analysis

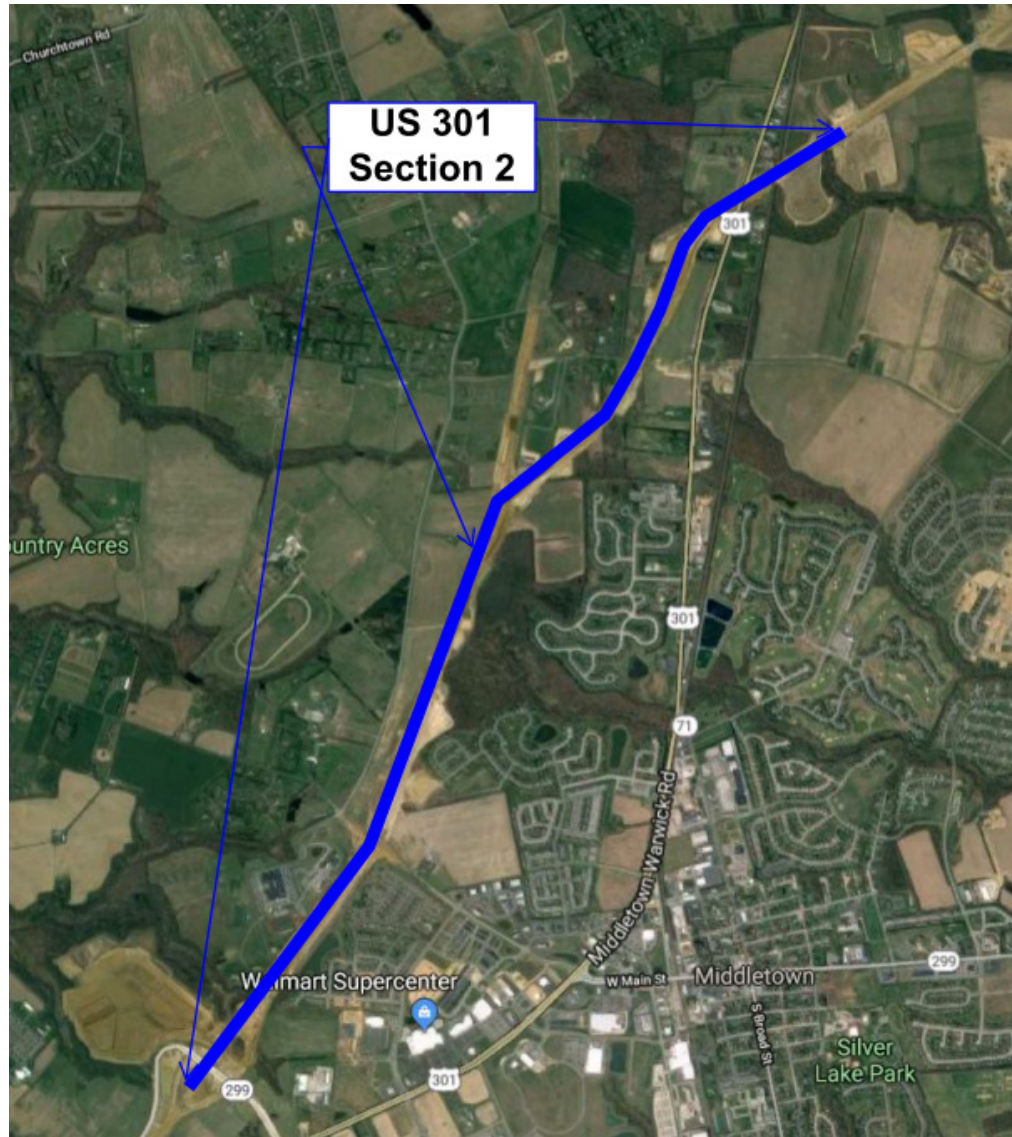
Conclusions

Acknowledgements

US 301 Section 2



US 301 Section 2



Project Overview

- New Alignment of US 301
- 4 Lane Limited Access Hwy
- Section 2, Approx. 4 miles
- New Castle County
- 3 Interchanges
- 8 Bridge Structures
- 2 Culverts
- 11 Cross Culverts



Project Overview

All of the 8 bridge abutments were founded on either PPC or Steel H-Piles driven piles.

Most structures used 14"x14" PPC piles.

Subsurface for these structures was consistent:
Dense to Very Dense
Silty Sand (SM, A-2-4)



Initial Design

All foundations for Section 2 bridges were designed prior to DeIDOT's release of their new Bridge Design Manual in 2015.



Delaware Department of Transportation

BRIDGE DESIGN MANUAL

2015 EDITION



Initial Design

Due to the sandy foundation soils only elastic settlement needed to be considered for approach embankment fills; however, consideration had to be given to the time that settlement would occur because of the silt compliment and low plasticity.

Estimates were calculated providing that ~ 4-inch settlement magnitude would be developed over a 3-4 week time period.

This amount of settlement, although elastic and in granular soils would develop downdrag (negative skin friction) forces if the piles were driven before the embankment settlement was realized.

Initial Construction Sequence

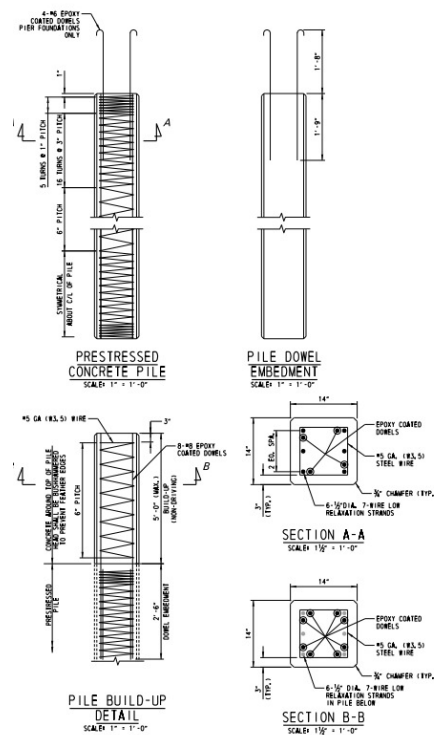
Based on the 3-4 week period to develop the settlement and to avoid having to account for downdrag a Construction Sequence of was recommended:

- Construct approach embankment to subgrade elevation.
- Install sleeves to receive the piles during the construction of embankment.
- Monitor the settlement during construction of the embankment and afterward to confirm settlement.
- Then drive piles in sleeves.
- Backfill annular space between pile



Initial Construction Sequence

- Settle 1st - Drive 2nd construction sequence was specified for each of the 8 bridge's abutment foundations.



- PILE NOTES**
- PILES SHALL BE 14"x14" PRECAST/PRESSED CONCRETE PILES. PILES SHALL NOT BE COATED. PILES SHALL BE CURED.
 - THE MINIMUM COMPRESSIVE STRENGTH FOR THE PRESTRESSED CONCRETE PILES AT THE AGE OF 28 DAYS SHALL BE 7,000 PSI. THE MINIMUM COMPRESSIVE STRENGTH AT TIME OF TRANSFER OF PRESSURE SHALL BE 7,014-800 PSI.
 - ALL PRESTRESSING STRANDS SHALL MEET THE REQUIREMENTS OF ASTM A186, GRADE 270, LOW RELAXATION. 1/2" DIAMETER STRANDS SHALL HAVE AN ULTIMATE STRENGTH OF 41,300 LBS.
 - IF BARS ARE USED, THEY SHALL BE #5 GAGE STEEL WIRE CONFORMING TO THE REQUIREMENTS OF ASTM A618 (ASTN A618).
 - THE SPLICING OF PRESTRESSED PRECAST CONCRETE PILES SHALL NOT BE PERMITTED.
 - REINFORCING STRAPS SHALL BE PROVIDED FOR THE ABUTMENT STEM AND BACKWALL TO RESIST THE LONGITUDINAL FORCES IN THE SUBSTRUCTURES.
 - PILE CAPPING SHALL BE INSTALLED AT THE PROPOSED PILE LOCATIONS DURING THE ABUTMENT WALL CONSTRUCTION.
 - A MINIMUM QUARANTINE PERIOD OF 30 DAYS IS REQUIRED AFTER THE CONSTRUCTION OF THE FULL HEIGHT OF THE FILL AT THE ABUTMENTS IS ACHIEVED.
 - PILES MAY NOT BE DRIVEN UNTIL AFTER COMPLETION OF THE QUARANTINE PERIOD.
 - TEST PILES MAY BE DRIVEN PRIOR TO PLACING WOE WALL. BACKFILL RESTRIKES OF THESE TEST PILES SHALL BE PERFORMED PRIOR TO PLACING WOE WALL. BACKFILL RESTRIKES SHALL BE PERFORMED WITHIN 14 DAYS OF PILE INSTALLATION. TEST PILES DRIVING RESISTANCE SHALL BE 255 KIP-FEET TO PLACING INSTRUMENTS. AFTER THE SETTLEMENT HAS BEEN ACHIEVED AND THE SUBSTRUCTURE HAS BEEN RELEASED BY THE ENGINEER, PRODUCTION PILES MAY BE INSTALLED. AT THIS POINT, THE TEST PILE SHALL BE ACTING AS A PRODUCTION PILE AND IT SHALL BE RE-STRUCK AS DIRECTED BY THE ENGINEER PRIOR TO PLACING ANY OTHER PRODUCTION PILES WITHIN PERMANENT UNDER-TRENCH 619001- PRODUCTION PILE RESTRIKES.
 - THE ENGINEER SHALL APPROVE THE COMPLETION OF THE QUARANTINE PERIOD, BASED ON RESULTS OF INSTRUMENTATION.
 - SEE THE SPECIAL PROVISIONS 202505 AND 202518 FOR SETTLEMENT MONITORING REQUIREMENTS.
 - ALL PILES SHALL BE DRIVEN TO THE NOMINAL PILE DRIVING RESISTANCE LISTED IN THE PILE INSTALLATION DATA TABLE.
 - TEST PILES SHALL BE 10 FEET LONGER THAN PRODUCTION PILES AS INDICATED ON PILE INSTALLATION DATA TABLE.
 - THE CONTRACTOR SHALL BE RESPONSIBLE FOR SUBMITTING A WAVE EQUATION ANALYSIS AND ALL OTHER INSTRUMENTATION IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS. THE WAVE EQUATION AND HIGH-STRAIN DYNAMIC PILE TESTING MUST BE SIGNED AND STAMPED BY A PROFESSIONAL ENGINEER LICENSED IN THE STATE OF DELAWARE IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS.
 - UPON COMPLETION OF THE HIGH-STRAIN DYNAMIC PILE TESTING THE CONTRACTOR SHALL SUBMIT A SIGNAL MATCHING ANALYSIS TO THE ENGINEER FOR REVIEW AND APPROVAL. IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS.
 - DEDOT STANDARD SPECIFICATION 619.111(016) SHALL BE MODIFIED BY REFERENCE TO SPECIAL PROVISIONS 61919 & 61933A.
 - PILE LENGTHS FOR ORDERING PURPOSES SHALL BE DETERMINED BY TEST PILES. A MINIMUM OF ONE (1) PILE PER SUBSTRUCTURE, AS SHOWN ON THE PLAN, SHALL BE DYNAMICALLY TESTED WITH SIGNAL MATCHING ANALYSIS BY THE CONTRACTOR IN ACCORDANCE WITH SPECIAL PROVISION 61919 AND 61933A. TEST AND PRODUCTION PILE RESTRIKES WILL BE PAID AS FOLLOWS:
 - ALL TEST PILES WILL BE RESTRIKED AFTER A WAITING PERIOD OF AT LEAST 48 HOURS. TEST PILE RESTRIKES SHALL BE INCIDENTAL TO THE INITIAL INSTALLATION OF THE PILE PROVIDED THEY ARE REQUESTED WITHIN FIVE WORKING DAYS FROM THE COMPLETION OF THE INITIAL DRIVE. IF TEST PILE RESTRIKES ARE REQUESTED AFTER THE FIVE WORKING DAYS FROM THE COMPLETION OF THE INITIAL DRIVE THEN THE TEST PILE RESTRIKES SHALL BE PAID AS NOTED IN SPECIAL PROVISION 61933A.
 - IF DIRECTED BY THE ENGINEER TO RESTRICK A PRODUCTION PILE, THE RESTRIKE OF THE PRODUCTION PILE SHALL BE PAID SEPARATELY UNDER ITEM NO. 619001.
 - THE DEPARTMENT RESERVES THE RIGHT TO PERFORM DYNAMIC TESTING OF RESTRIKES.
 - PROVIDE 1 1/2" DIAMETER PREFORMED HOLES IN PILE HEAD AT THE DONUT LOCATIONS. DONUTS SHALL BE INSTALLED WITH PILE WITH AN APPROVED EPOXY DONUT. PRIOR TO THE CAPPING, PRODUCTION PERFORMANCE TEST SHALL BE CONDUCTED TO ENSURE THAT WATER AND FOREIGN MATERIAL DOES NOT ENTER THE PREFORMED HOLES.
 - MINIMUM COMPRESSIVE STRENGTH OF EPOXY GROUT SHALL BE 7,000 PSI.
 - THE COMPRESSIVE STRENGTH OF THE PILE BUILD-UP SHALL BE 7,000 PSI.
 - DONUT HOLES SHALL BE POSITIONED TO MAINTAIN A 1" CLEAR DISTANCE FROM ALL PRESTRESSING STRANDS IN THE PILE.
- ADDITIONAL NOTES FOR CAST-IN-PLACE ALTERNATE**
- A CONTRACTOR'S ALTERNATE OF USING 14" CAST-IN-PLACE CONCRETE PILES (14" MONOTUBES) IS ALLOWED. ASSUME A ONE TO ONE SUBSTITUTION.
 - MONOTUBE HOLES SHALL HAVE A 3/8" GROUT THICKNESS, AN 8 IN TIP WITH A CLOSED CONICAL POINT, 14 IN BUTT, AND A 15 FT TAPER AT 0.40 IN/FT.
 - THE ESTIMATED TIP ELEVATION SHALL BE 21 FT AND 24 FT FOR ABUTMENTS 1 AND 2 RESPECTIVELY.
 - A NOMINAL PILE DRIVING RESISTANCE OF 255 KIPS SHALL BE OBTAINED.

SEE RFI 0033

- PICK-UP NOTES**
- UNLESS SPECIAL LIFTING DEVICES ARE ATTACHED FOR PICK-UP, PICK-UP POINTS SHALL BE PLAINLY MARKED ON ALL PILES AFTER REMOVAL OF THE FORM. THE PILE SHALL BE SUPPORTED ONLY AT THE INDICATED PICK-UP POINTS WHILE BEING STORED OR HANDLED.
 - THE USE OF PROPER RIGGING IS REQUIRED TO INSURE THAT THE PICK-UP POINTS REMAIN IN A STRAIGHT LINE DURING LIFTING AND WHEN POSITIONING THE PILE FOR DRIVING.
 - THE USE OF SPECIAL EMBEDDED OR ATTACHED LIFTING DEVICES, THE USE OF OTHER PICK-UP LOCATIONS OR ANY OTHER METHOD OF PICK-UP SHALL BE SUBJECT TO THE APPROVAL OF THE ENGINEER.

PILE INSTALLATION DATA				
SUBSTRUCTURE UNITS	DESIGN DATA		ACTUAL FIELD DATA	
	NOMINAL PILE DRIVING RESISTANCE (KIP-FEET)	ESTIMATED PILE TIP ELEVATION	AVERAGE MINIMUM TIP ELEVATION	AVERAGE MAXIMUM TIP ELEVATION
ABUTMENT 1	255	27		
ABUTMENT 2	255	24		

ABUTMENT 1 PILE DRIVING INFORMATION	
PILE SIZE AND TYPE:	
ACTUAL BEARING OBTAINED:	
HAMMER TYPE:	
PILE HAMMER ENERGY:	
SPECIAL DRIVING CONDITIONS AND COMMENTS:	

ABUTMENT 2 PILE DRIVING INFORMATION	
PILE SIZE AND TYPE:	
ACTUAL BEARING OBTAINED:	
HAMMER TYPE:	
PILE HAMMER ENERGY:	
SPECIAL DRIVING CONDITIONS AND COMMENTS:	

CROSS REFERENCE NOTES
1. FOR PILE CASING DETAIL, SEE DML-1-470 AB-5.

1-470 R-2

RFI 0033

In March 2016 after award of the Construction Contract to Allan Myers; AECOM received a RFI #0033 asking to amend the Construction Sequence to allow driving of the piles 1st to eliminate the need for the settlement quarantine.



AECOM provided the following response:

- *AECOM has accepted the proposed driving sequence to drive production piles prior to placing MSE wall backfill.*
- *However, pile casings will still be required as indicated in the contract plans.*
- *Piles are to be re-struck providing a minimum 6" of movement to release negative skin friction.*
- *Pile re-strikes are to be performed prior to backfilling the annular space between the piles and casings with Fine Aggregates as indicated on the contract plans.*

Response

In early April 2016, DeIDOT's Bridge group reached out to each of the US 301 Section Designers and asked that they reconsider prescribing driving of piles post construction of the surrounding embankments. Especially in MSE approaches. DeIDOT requested the use of the new BDM Section 210.7.1.6.2 on Downdrag.

210.7.1.6.2 —Downdrag

The following shall supplement A10.7.1.6.2

Downdrag and transient loads such as live loads should not be considered as acting simultaneously on any load combination. For the different load cases, use only the higher of these two factored loads (factored downdrag versus factored transient loads).

Response

5 of 8 Section 2 bridge structures exhibited a factored DD Load Condition in excess of the Factored Resistance of the piles:

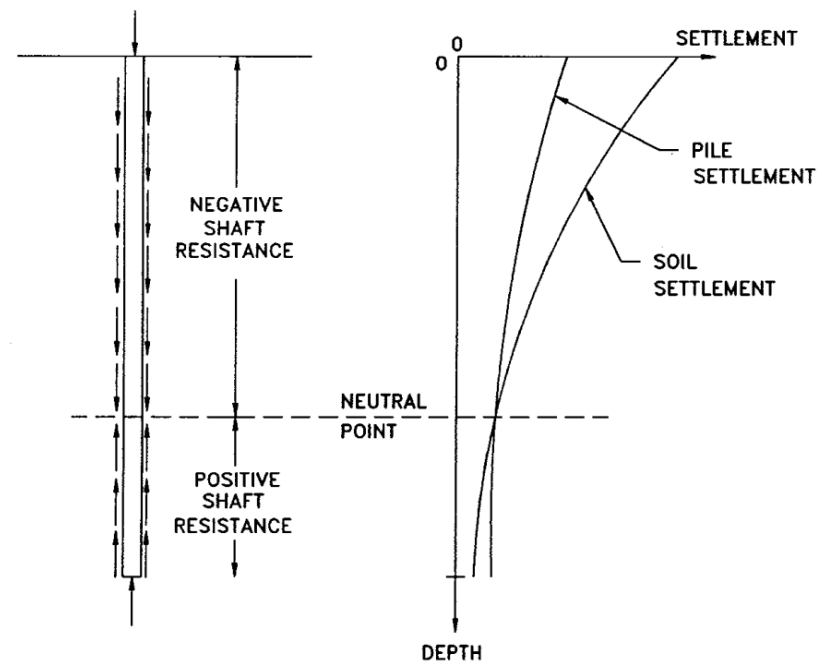
- BR1-468
- BR1-470
- BR1-472
- BR1-507
- BR1-477



Downdrag Analysis

AECOM approach:

- Embankment approach fill would be placed on med. dense sandy soil over a dense to v. dense sand.
- Elastic settlement was calculated using the Hough method for granular soils (cons.)
- Extent/limit of DD was est. from settlement calc (neutral axis)
- Magnitude of DD est. from skin friction of pile. (used Driven)
- Factored DD (using 1.05 factor from A3.4.1-2) + DC+DW was compared to factored DC + DW+ LL.
- Where DD + DC exceeded the factored pile resistance mitigation meas. were recommended.



Downdrag Analysis

Bridge 1-472 (BR2-3)			
Load Type	Unfactored Load	Applicable Load Factor	
DC Load	112.06	1.25	kip/pile
DW Load	7.79	1.5	kip/pile
LL	28.89	1.75	kip/pile
DD	113.5	1.05	kip/pile
Total Factor Load (LL)		202.3175	kip/pile
Total Factored Load (DD)		270.935	kip/pile
Nominal Resistance, per plans =		361	kip/pile
Factored Resistance =		234.65	kip/pile

Downdrag Mitigation Alternatives

1. Per the previous RFI 0033 response, “...Piles are to be re-struck providing a minimum 6” of movement to release negative skin friction once approach emb is to subgrade elev. Pile re-strikes are to be performed prior to backfilling the annular space between the piles and casings...”
2. Pre-drill at each of the pile locations to a depth of 10’-0” below existing grade, install casing, drive piles to nominal driving resistance per plan, backfill annular space with fine aggregate, extend casing through MSE approach fill and backfill remaining casing once MSE construction is completed.
3. Apply a friction reducer (bitumen coating or equivalent) to the top 10’-0” of each pile that will be embedded below the existing ground surface in the final driven position (depth), install casing around the pile, construct the MSE approach fill and backfill casing with fine aggregate once MSE construction is completed.
4. Drive the piles deeper to the revised nominal driving resistance to account for DD (see attached calculations). The additional depth of pile would be determined during the test pile operation. If the additional depth can be achieved without over-stressing the piles, then the production piles would be driven to similar revised capacity, casing would be installed around each pile, the MSE approach would be constructed and the casing would be backfilled with fine aggregate. For this alternative revised contract plans would have to be developed by the Designer, along with the pertinent calculations to determine if the additional pile resistance exceeds the structural capacity of the pile. Also, due to the potential for over-stressing the pile as determined by the Design-Phase Test Pile program, August 2010, additional scrutiny would have to be paid to the results of the PDA/CAPWAP analysis. Therefore, this approach would not be a preferred alternative for construction of these structures.

Contractor Preferred Alternative

“Apply a friction reducer (bitumen coating or equivalent) to the top 10’-0” of each pile that will be embedded below the existing ground surface...”



Friction Reducer

- Designer provided spec for Bitumen Coating for Friction Reducer.
- Limits of friction reducer to be provided prior to Test Pile operation.
- Results of test pile operation determine length of production piles and friction reducer limits for production piles

CONCRETE PILING BITUMEN COATING

This section shall include the following:

The work shall consist of furnishing and applying bitumen coating and primer to Precast, Pre-stressed Concrete (PPC) pile surfaces as required in the plans and as specified herein.

MATERIALS:

- A. Bitumen Coating. Canal Liner Bitumen conforming to AASHTO M 239 (ASTM D 2521) shall be used for the bitumen coating and shall have a softening point of 190 to 200 degrees F, a penetration of 56 to 61 at 77°F, and a ductility in excess of 1.4" at 77°F.
- B. Primer. Primer shall conform to the requirements of AASHTO M116 (ASTM D 41).

Application of Bitumen

Applying the Primer:



Applying the Bitumen:



Alternate Friction Reducer

- Due to the Safety and Environmental Hazards associated with applying hot bitumen (~ 300°F) the Contractor requested the use of an alternate friction reducer that could be painted or sprayed on the piles.
- DeIDOT gave provisional approval to use Slickcoat™

Slickcoat™

A FRICTION REDUCTION SYSTEM FOR COATING PILES, DRILLED SHAFTS AND SHEET PILING PRIOR TO INSTALLATION IN ORDER TO REDUCE FRICTION IN CONSTRUCTION APPLICATIONS WHERE NEGATIVE SKIN FRICTION, DOWNDRAG FORCES, EASE OF INSTALLATION AND EXTRACTION ARE OF CONCERN.

ADVANTAGES

- Reduces peripheral anomaly activity in drilled shaft construction by creating an excellent plane between the drilled shaft casing and the cast-in-place concrete
- Realize substantial friction reduction
- Reduces uplift
- Prolongs the life of piles, sheets and casings
- Durable abrasion resistance
- Save valuable time
- Improved ease of installation, and an expeditious extraction process
- Reduce maintenance costs
- Reduce tidal friction on submerged piling

CONSTRUCTION BENEFITS

- Highly resistant to corrosion and chemicals common to construction
- Surfaces stay clean reducing maintenance costs
- Water based, the environment is protected since toxins, chemicals, and harmful metals are not leached into the ecosystem as with bitumen coatings
- Excellent bond breaking characteristics
- Cleans up with water
- Waterproof in a cured state
- Stays in place even during hot weather conditions
- Bonds to pile or casing
- Provides excellent friction reduction between the earth and piling
- Durable
- Apply with conventional equipment
- Replaces bitumen coatings which are unreliable, hazardous to work with, and difficult to maintain on the pile surface during driving, especially under high temperatures

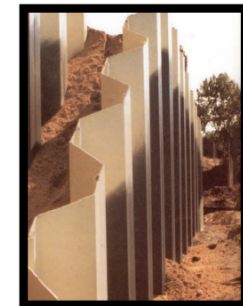
Patents: 5,931,604
6,234,720 B1 P
6,471,446



Driven Piles



Shaft Casings



Sheet Piling

Friction Reducer

Designer estimated the extent of the Slickcoat.

Reduced DD forces were considered due to the application of the friction reducer

<u>BR 1-470 Slick-Coat Extent</u>			
Note: all dimensions in feet			
ABUTMENT 1	BPCE NB	BPCE SB	TLPE
	78	80	62
ABUTMENT 2	BPCE NB	BPCE SB	TLPE
	80.25	81.5	61
Stick-up	NB Abutment 1	SB Abutment 1	
	16	18	
	NB Abutment 2	NB Abutment 1	
	19.25	20.5	
	<u>Northbound</u>	<u>Southbound</u>	
Pile Embedment in pile cap	1	1	
Starting Depth of Slick-coat	17	19	
Downdrag extent	10	10	
Ending Depth of Slick-coat	27	29	

Friction Reducer



Test Piles

Starting in June 2016, Century Engineering, Inc. (Century) CM/CI for the 301 project started coordinating Test Pile results with AECOM.

DELAWARE DEPARTMENT OF TRANSPORTATION	
CONTRACT: T200911303	F.A.P. No. NH-2015(23)
DATE 6-21-2016	
DESIGNER'S TEST PILE RECORD	
FOUNDATION FOR BR. # 1-477	
CONTRACTOR <u>Allan Myers, Inc.</u>	TYPE OF PILE <u>Precast Concrete</u>
FOOTING DESCRIPTION <u>Abutment 2, Southbound</u>	TIP DIAM. <u>14 inch</u> BUTT DIAM. <u>14 inch</u>
PILE NO. <u>TP 77</u>	PROPOSED TEST PILE LENGTH <u>64 FT</u> RATE OF PILE BATTER IF APPLICABLE <u>N/A</u>
PILE HAMMER MAKE <u>ICE</u> ; MODEL <u>1-30v2</u>	BOTTOM OF FOOTING ELEVATION <u>EL 37 (+1.0 ft embedment)</u>
NOMINAL BEARING <u>400 Kips</u>	MINIMUM PILE TIP ELEVATION REQUIRED <u>EL -11.0</u> TIP ELEVATION ACHIEVED (REMEMBER TO CORRECT IF BATTERED) <u>EL -12</u>
INFORMATION FROM CONTRACTOR'S WAVE EQUATION SUBMITTAL	
PREDICTED BLOWS PER FOOT TO ACHIEVE BEARING <u>34</u>	PREDICTED TIP ELEVATION TO ACHIEVE BEARING <u>EL -16</u>
PREDICTED CAPACITY AT FINAL TIP ELEVATION <u>400 Kips</u>	PREDICTED STROKE HEIGHT TO ACHIEVE BEARING <u>7.25 ft</u>
MAXIMUM ALLOWABLE STRESSES IN THE PILE (TENSION) <u>1,038 psi</u>	PILE CUSHION TYPE: <u>Plywood</u> AND THICKNESS: <u>10 inch</u>
MAXIMUM ALLOWABLE STRESSES IN THE PILE (COMPRESSION) <u>4,290 psi</u>	
INFORMATION FROM PDA DURING DRIVING	
BLOWS PER FOOT AT END OF DRIVING <u>54</u>	CAPACITY AT END OF DRIVING <u>525 Kips</u>
BLOWS IN LAST 4 INCHES OF DRIVING _____	STROKE HEIGHT AT END OF DRIVING <u>10.7 - 11.2 ft.</u>
RECORDED MAXIMUM STRESSES (TENSION) IN THE PILE <u>490 psi</u>	
RECORDED MAXIMUM STRESSES (COMPRESSION) IN THE PILE <u>4,190 psi</u>	
TEST PILE RESTRICKE INFORMATION	
RESTRICKE STROKE HEIGHT OF HAMMER <u>N/A</u>	PILE MOVEMENT AFTER RESTRICKE IN INCHES <u>N/A</u>
INFORMATION FROM CAPWAP ANALYSIS	
CAPACITY ESTIMATE FROM REP. BLOW AT THE END OF INITIAL DRIVE: <u>510 Kips</u>	CAPACITY ESTIMATE FROM RESTRICKE REP. BLOWS: <u>N/A Kips</u>
RECOMMENDATIONS FOR PRODUCTION PILES REPRESENTED BY THIS TEST PILE	
PRODUCTION PILE ORDER LENGTH <u>58 LF</u>	MINIMUM STROKE HEIGHT REQUIRED <u>9.5 ft</u>
BLOWS PER FOOT REQUIRED TO ACHIEVE BEARING <u>54 Blows/ft.</u>	MAXIMUM STROKE HEIGHT <u>11.0 ft</u>
ADDITIONAL COMMENTS / RECOMMENDATIONS	
<ul style="list-style-type: none"> - Recommended production pile order length is 58 feet for both plumb and batter piles - Minimum tip remains as designed at EL -11.0. The tip is critical and should be achieved unless the pile reaches refusal. - Operate the hammer at fuel setting 2 for all piles in this footing - Use a new 10 inch thick pile cushion for every pile. Replace the cushion if 1,000 blows are reached on an individual pile, or if excessive deterioration is witnessed. - Achieve a minimum of 54 Blows per foot in the last foot of driving with a minimum hammer stroke height of 9.5 feet. Maximum stroke height should be limited to 11.0 feet so that the pile is not overstressed - Refusal is defined as 120 Blows/foot or 10 blows/inch should that occur during driving. Note that if refusal is reached during driving, the operation should be stopped even if the minimum tip has not been reached in order to avoid damage to the pile and/or hammer. - Slickcoat coating shall be applied to only the plumb piles, starting 5 feet below the top of the pile for a length of 20 feet, stopping 25 feet below the top of the pile. 	
Approx. Ground EL 42.00	Projected Final plumb pile length: (EL 38) - (EL -13.0) = 51 ft
Test Pile Driven Length: 56 ft	Projected batter pile length: 52.6 ft
Test Pile Tip EL achieved: EL -12	Recommend 58 ft. for production pile order length to account for variability
Based upon adding 50% of the skin friction estimated from the PDA results between EL. 37 and EL. 17 to the strength load to account for downdrag, the required Nominal Capacity is 526 kips for Abutment 2 SB. Based upon the dynamic test results for Abutment 2 SB, the plumb and battered piles should be installed to estimated tip elevation of -13 with a minimum final penetration resistance of 54 Blows/foot using a minimum stroke of 9.5-feet	

Test Piles/Production Piles

Test Pile in Leads on BR 1-477



Test Piles/Production Piles

Test Pile being driven on BR 1-477



Test Piles/Production Piles

Completed Test Pile w/ Template BR 1-477



Test Piles/Production Piles

Slickcoat on H-piles at BR1-507



Test Piles/Production Piles

Test Piles being driven BR 1-507



Test Piles/Production Piles

Abutment Production Piles at BR 1-507



Test Piles/Production Piles

Abutment 2 BR 1-475



Test Piles/Production Piles

Abutment 2 BR 1-475



Test Piles/Production Piles

Abutment 2 BR 1-475



Test Piles/Production Piles

Abutment 2 BR 1-475



Conclusions

- **Total Bid for the project was ~ \$94MM**
- **Cost for Slickcoat material/application = \$53K**
- **Total cost savings for elimination of settlement monitoring/abutment for 5 bridges = - \$40K**
- **Net savings of only \$13K for the project; however...**

Conclusions

- **By allowing the Contractor to drive the piles 1st and eliminate the quarantine/settlement monitoring period per abutment provided a schedule savings of ~30 days/abutment.**
- **For 10 abutments on 5 bridges that equates to 300 days of schedule savings.**
- **This construction sequence also allowed the Contractor to keep the Bridge Crews working continuously without delay adding to the overall efficiency of the project.**

Acknowledgements

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- **R K & K, Inc.**
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- **Allan Myers, Inc.**
 - Travis Kirchner, Proj. Mgr.

QUESTIONS?



Drone Video Footage

<https://www.youtube.com/watch?v=rHahgUVpQ9g>